FIG. 2. HAUNCH OF THE 285-FT. ARCH AT BERLIN

The total cost was about $300,000. The contractor for the fabrication and erection of the superstructure was the Dortmund Union plant of the Deutsch-Luxemburgische Bergwerks und Hütten Co.

Bridge Carrying Highway and Irrigation Flume

A double-deck bridge with a roadway above and a wood-stave pipe flume below is being built for the Sun River irrigation project (Montana) of the United States Reclamation Service. It is to cross the Sun River. The bridge will consist of two 110-ft. truss spans, with trusses 16 ft. deep spaced 14½ ft. c. to c. The upper-deck framing is placed considerably below the chords, so that the trusses form the parapets. The framing is simple (see drawing). A single thickness of planking forms the floor. The laterals in this deck are single 3x2½-in. angles. The lower deck, for the 8-ft. pipe flume, has floor-beams of 15-in. I-beams framed between the bottom chords at the posts. The pipe is thus supported at panel points only, or at intervals of 13 ft. 9 in. At each floor-beam is a plate-girder cradle for the pipe. To allow for longitudinal movement of the span, the cradle is carried clear of the floor-beam, having each end supported by a vertical link with pin connections to the end of the cradle and a bracket on the floor-beam.

The original design provided for a cradle composed of two triangular brackets on the floor-beams, one on each side of the pipe. This made no provision for expansion movements of the bridge in relation to the pipe, although the spans are provided with roller end supports while the pipe is held in fixed position. The range of temperature is very great; and as it is anticipated that the bridge spans may move as much as 1½ in., the flexible cradle support was substituted for the rigid supports originally designed.

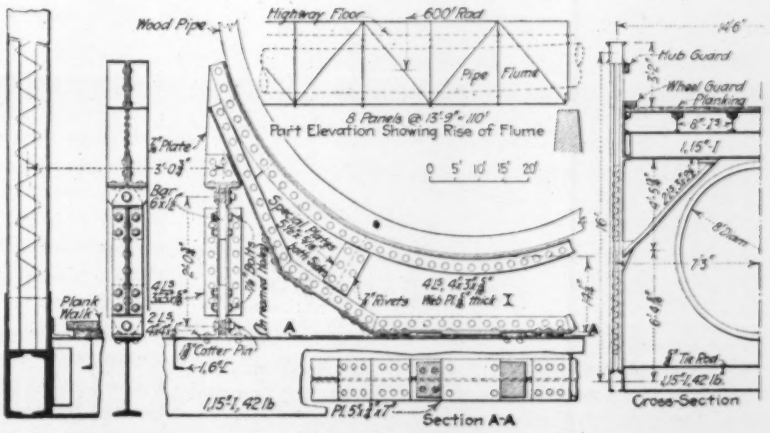
The highway floor on the upper deck is carried on floor-beams of 15-in. I-beams with six lines of stringers, four of 8-in. I-beams and two of 8-in. channels fitted against the truss posts. These stringers are in two-panel lengths, breaking joints over alternate floor-beams. On the stringers are 1x6-in. spiking pieces, to which is spiked a single layer of planking. A wheel guard on each side of the floor is secured by hook bolts, and a timber hub guard is bolted to the truss posts.

On each side of the lower deck are a pair of 6-in. channels, framed between the floor-beams. Timber crosspieces, 2x4 in., carry two lines of plank forming a footwalk. There are two lines of longitudinal ⅝-in. tie-rods through the floor-beams. The laterals are single angles, 3x3 in.

At one end of the bridge the pipe rises on a vertical curve of 600-ft. radius, and the floor-beams are raised gradually to give the change in elevation. The top chords are of trough section, with two 12-in. web plates, a 14-in. cover plate and four 2½x2½-in. angles. Each bottom chord is composed of a pair of 12-in. channels with flanges inward. All the posts and hangers are composed of four laced angles, 2½x2½ in., including the vertical posts on the piers, which support the top-chord extensions carrying the roadway deck. The diagonals are pairs of 12-in. and 9-in. channels in the first two panels from the end respectively and pairs of 3x3-in. angles in the middle panels.

The bridge is designed for a dead-load of 4,600 lb. per lin.ft. of bridge; 3,600 lb. of this is represented by the pipe full of water. The highway live-load is assumed as 1,300 lb. per lin.ft. The wind load is taken at 30 lb. per sq.ft. on 1½ times the vertical projection of the structure, plus 2½ times the projected area of the pipe. No allowance was made for impact, as this was assumed to be negligible as compared with the heavy dead-load. The total weight of steel in the two spans will amount to about 200,000 lb.

The Des Moines Bridge and Iron Works, Des Moines, Iowa, has the contract for the superstructure. For information we are indebted to E. A. Moritz, Acting Chief of Construction, United States Reclamation Service.



DOUBLE-DECK BRIDGE CARRYING A HIGHWAY AND PIPE FLUME; SUN RIVER IRRIGATION PROJECT, MONTANA

Handling Retail Coal in a Concrete Cylinder Plant

By Charles H. Higgins*

SYNOPSIS—Routing coal from New Jersey terminals to New York City. Construction of this plant was described in "Engineering News," Feb. 24. General operation. Coal-hoisting machinery. Power plant.

A large concrete retail coal-handling plant, shown in Fig. 1, has just been built at the foot of East 19th St., New York City, the owner being O. H. Perry & Son, Inc. Its capacity for unloading coal from barges is at the rate of 2 tons per min., which amounts to more than 1,000 tons in a working day.

Coal for use in Manhattan is dumped into boats or barges of 250 to 500 tons' capacity at the railway terminals along the New Jersey side of the North River and at Perth Amboy, N. J., and towed to bulkhead walls on Manhattan Island. When the coal barge is pulled alongside the bulkhead of the Perry plant, under a boom which is 100 ft. above the barge, a grab bucket of 1½ tons' capacity, swinging from a trolley on the boom, hoists the coal 90 ft. vertically. The trolley is pulled in horizontally, and the coal is dumped into a hopper just below the heel of the boom, the entire movement being controlled by an operator standing in the house alongside the hopper. From the hopper the coal flows by gravity through a system of steel chutes to any selected one of 13 concrete bins or pockets. One of these pockets is for bituminous coal; the other 12 are for storing the different "steam and prepared sizes" of anthracite, of which there are at least six to be handled.

The coal is directed by means of gates to any pocket desired. These gates are arranged so as to be easily operated from the floor of the engine-boiler room. In addition to directing the flow of coal to the proper pocket the fireman who operates the gate may direct the coal into either one of two bunkers which are located on the boiler-room floor and from which he conveniently obtains coal for firing the boiler.

As the bins or pockets are 40 ft. deep, the breakage in the larger or "prepared" sizes would be excessive. To prevent this, flow ladders are provided in the pockets where the larger sizes of coal are to be stored. These flow ladders consist of a series of baffles, through which the coal passes without acquiring excessive momentum.

To take the coal from these storage pockets, trucks pass through the driveways beneath the concrete platform on which the pockets are supported, and the truck driver, by opening a gate numbered to correspond with his instructions, allows the coal to flow over a screen into his truck. The screenings, or dust, fall through the screen into the dust bins, which are located between the columns on each side of the driveways. The truck is driven over granite-block pavement to one of two platform scales below the second story of the office building, the first story being omitted for part of its length, to make room for these driveways with scales. The weight is read on the first floor of the office building on a scale beam, near a window overlooking the scale platforms. If the order is for a definite weight, the weight is corrected from small "off and on" pockets above the scales and directly under the second floor of the office. After the coal is weighed and the truck has driven off the scale, the coal may be sprinkled from a water pipe and sprinkler extending out from the office at such height and location as to permit trucks to drive under.

The accumulation of screenings in the dust bins and all sweepings of the yard are dumped into the elevator

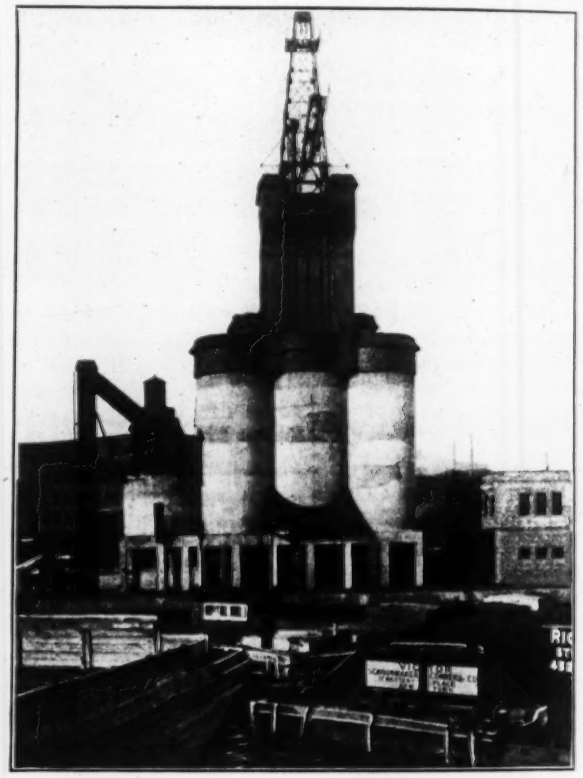


FIG. 1. EAST RIVER FACE OF THE NEW PERRY COAL PLANT; BARGES IN FOREGROUND

boot near the southeast corner of the plant and hoisted by a bucket elevator to the rescreening house, where the coal flows into a revolving screen that separates it into five sizes and drops each size into a separate bin of the rescreening pockets. The bucket elevator and screen are driven by an electric motor. The dust—that is to say, the coal passing a ⅜-in. screen—falls into the low cylinder pocket nearest the river, from which by a chute and gate it may be slid into an empty boat, be hoisted by the main grab bucket and passed into a bunker on the engine-boiler room floor, where it is available for firing the boiler. The other low cylinder is divided into four pockets by diaphragm walls, and the coal is drawn off into a truck by gates located in the bottom. There are similar overhead gates in the bottom of the dust

*Consulting Engineer, 30 Church St., New York City.

bin, from which the dust may be drawn off into trucks. As already stated, coal may be deposited in the pockets and drawn out at the rate of 2 tons per min. The capacity of the pockets (some 2,500 tons) represents the storage capacity and allows for keeping a supply of each of the different sizes on hand.

After careful examinations of the merits of different methods of hoisting and of moving coal horizontally to the different pockets the method determined upon was to erect a steel tower, about 90 ft. high, supported and anchored to the concrete cylinders. The tower was designed to support a 42-ft. horizontal boom with the heel seated about 40 ft. from the top of the tower; also to support a steel hopper with an opening in the top about 10 ft. square, located at the front of the tower and about 15 ft. below the boom. By means of an ordinary clamshell bucket and trolley operating on the horizontal boom, coal might be dug from boats lying alongside the bulkhead and dumped into the hopper.

The method chosen for distributing the coal from the hopper to the various bins was by a system of chutes 24 in. wide and 18 in. deep, of rectangular cross-section and made up of steel plates and angles. Considerable difference of opinion arose as to what angle of slope such chutes should be given in order that coal of the different sizes handled might flow freely and, at the same time, with not greater speed than necessary. This problem was somewhat complicated by the fact that several turns were necessary to take the coal from the hopper to the bin, as can be seen on the drawing. An average angle of 37° was finally determined upon, the angle being made somewhat greater for the first two-thirds of the distance to the bins and a corresponding amount less for the remaining third. No difficulty has been experienced, the coal flowing freely.

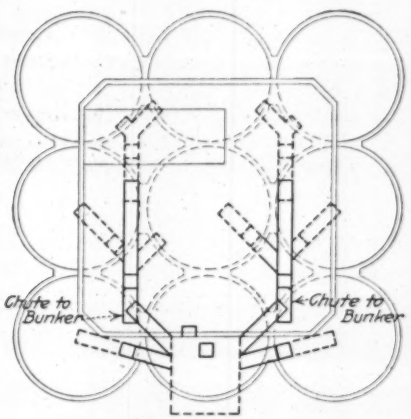


FIG. 3. LAYOUT OF CHUTES

A baffle with a slide gate, located at the bottom of the hopper, directly above the beginning of the chute system, permits regulation of the size of the opening from the hopper to the chute system. By this means a great surge of coal is avoided when the bucket dumps.

The gates in the chute system are of the flap type and are so arranged at change of direction points that in opening the chute to one bin they close the chute to another. Some slight adjustment proved necessary to adapt these gates to the conditions, but they are now working very satisfactorily. The chutes are covered by light steel plates, fastened in place with bolts for most of the distance, to prevent coal from flying about.

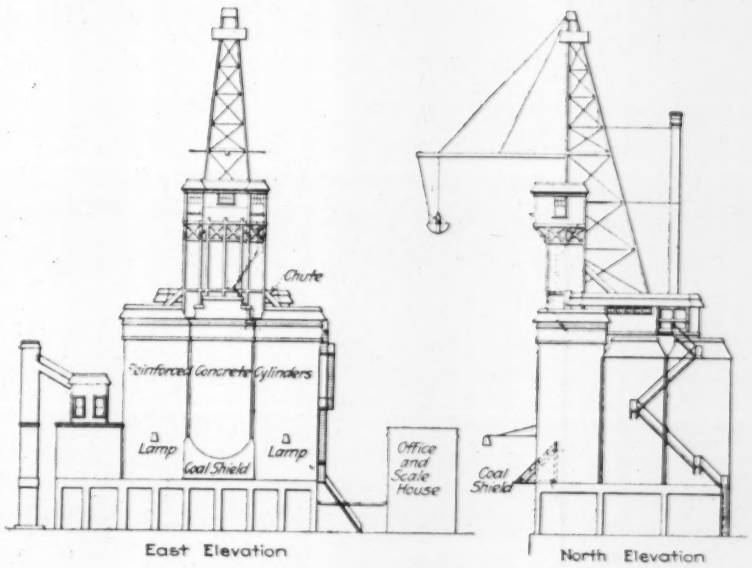


FIG. 2. HEADHOUSE OF COAL-HANDLING PLANT

The bucket is operated by a double-drum double cylinder hoisting engine near the end of the tower and above the coal pockets. A second engine, superimposed on the first, is provided to operate the carriage, which is also properly counterweighted. A horizontal fire-tube boiler was installed to supply steam for the hoisting engines.

The engines, trolley and bucket are provided with complete control, so as to be precisely and conveniently operated by one man standing in the control house alongside the hopper. To carry the engines and appurtenances and to distribute the load and brace the structure, a floor of steel I-beams was constructed at an elevation 7 ft. above the top of the concrete pockets, as indicated. On the I-beams was cast a reinforced-concrete slab 5 in. thick, provided with hatches and gratings to give access to the pockets below. At each of these hatches and gratings there is a wooden stairway, and below, at the level of the pockets, are plank runways to give access for trimming, etc.

The rescreening plant consists of a concrete waterproofed boot with bucket elevator, of a capacity of 15 tons per hr., operated by a 7½-hp. motor in the screenroom. The same motor operates a 42-in. locked, crimped steel-wire, revolving screen 20-ft. long, with four partitions that divide the coal into five sizes. When screened, the coal chutes directly into the pockets of the rescreening plant.

The Perry plant was designed by the writer and was erected under his supervision, with Ralph H. Perry acting for the owner. The coal-handling machinery, headhouse and appurtenances were furnished by the Guarantee Construction Co., New York City.

Reinforced-Concrete Dams of the Inverted-Arch Type

By W. T. Ellington*

The interests employing the writer have been engaged since the year 1907 in developing hydro-electric power on the streams draining the eastern slope of the Sierra Nevada Mountains in Inyo and Mono Counties, California. In the course of this development they have constructed dams of various types, principally, however, of loose rock-fills, which type has seemed best adapted to the conditions where the transportation charges against cement and other materials average about $20 per ton.

These rock-fill dams have been constructed with a timber facing of planks between which was placed sail cloth covered with asphaltum, thereby rendering them practically impervious to water. This type of construction has served and is serving its purpose very well, but the disadvantages of a timber face alternately wet and dry have caused our engineers to view with interest the new types of dams that have been constructed, such as the Eastwood and Jorgensen and Ambursen.

The storage reservoirs are in all cases formed by dams across the outlets of glacial lakes at elevations varying from 8,000 to 10,000 ft., and the sites are ideal for masonry structures. Gravity masonry dams are, of course, not to be considered, because of the cost of cement. The types of patented dams mentioned lend themselves well to the conditions and are nearly as cheap as the rock-fill. The cost of the concrete in place for these patented dams under the conditions outlined is about $25 per cu.yd.

It occurred to the writer that a saving might be made by making all possible use of steel in tension with an allowable stress of 15,000 lb. per sq.in. against an allowable stress on concrete in compression of 500 lb. per sq.in., the transportation charges on steel and on cement being equal per ton. The idea is perhaps best illustrated by a reinforced-concrete tank.

The simplest application of the principle would seem to be in the form of a number of semicircular inverted arches, or, if you please, half-tanks supported by buttresses at the springing line. With these arches arranged to form a dam with a vertical water front, the shear and overturning moment were found to be so great as to require a prohibitive amount of concrete in the buttresses. Our calculations were made for a dam with a height of 80 ft., as we were at that time preparing to construct one of that height. By inclining the suspended arches at an angle of 45°, however, and with an arch span of 35 ft., we found the cost of material to be about 35% less than the cost for any other type that we had investigated. We then caused a search to be made of the United States Patent Office records with the hope of securing data or information dealing with this design. This search revealed that a large number of patents had been issued covering substantially the points outlined, but none of the patents went into detailed investigation of the stresses. It is of passing interest to mention that nearly all the patents were issued to British subjects.

We then began a study of the stresses, which are quite involved, and as a result of this study we abandoned all hope of making a practical application of the suspension-arch principle, principally because of excessive [illegible] at the foundation line.

The writer has no knowledge of any dams having been constructed under the patents issued or along similar lines and is of the opinion that the application of the suspended-arch principle to dams is impractical. He feels, however, that the profession would be benefited by a discussion of the subject, which might prevent improper application of the principles involved, and will gladly correspond with any engineers who may be interested.

*Engineer, the Nevada-California Power Co., Riverside, Calif.

Standard Concrete Abutments for Michigan Bridges

By C. V. Dewart*

The economical design of abutments, more especially of those which must retain a great depth of embankment, presents a difficult problem to the engineer. The type of abutment shown here has been given a thorough trial by the Michigan State Highway Department and found to be a little more satisfactory and more economical than any of the other designs in more common use.

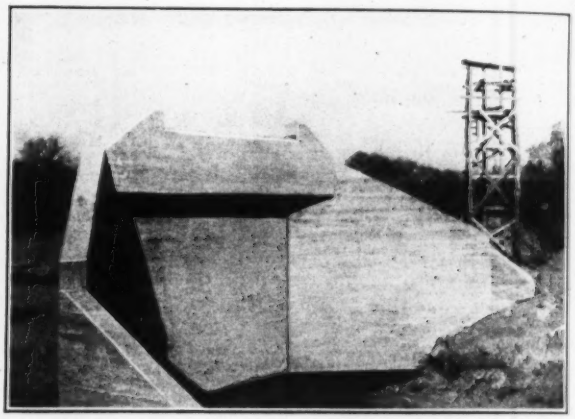


FIG. 1. A 23½-FT. ABUTMENT READY FOR BACKFILL

In highway work more than in any other line it is of the utmost importance to make plans as clear as possible, so that they may be understood by and constructed by the inexperienced contractor, with the least amount of supervision. With this end in view, all battered surfaces have been omitted, and a perspective drawing is shown. Tables of dimensions and of reinforcing bars required also make it possible to show on one sheet, in a clear and concise form, everything complete for various abutments ranging in depth from 10 to 20 ft. above the top of the footing.

The design embodies an unusual combination of principles in abutment construction, but nevertheless they are all principles that have proved their worth separately. The main wall may be designed as a slab supported on four sides—at the two ends by the counterfort wings, which should make an angle of preferably not less than 45° with the main wall; on the bottom by the footing, and on top by the horizontal girder formed by the bridge seat. The wings may be continued straight on down at any desired slope until they run out at the footing.

*Bridge Engineer, State Highway Department, Lansing, Mich.

thus forming a triangular slab supported on two sides. This style of wing is better suited to comparatively low abutments.

For high abutments of a greater height than 10 ft., however, it is usually found best to turn the wings back, as shown in Fig. 2, parallel with the roadway, thus limiting the width of the structure to the width of the right-of-way, providing an additional cutoff wall against scour and allowing room for gutters to take care of the drainage along each side of the embankment. This style of wing forms a quadrilateral supported on three sides by the main wall of the abutment, the footing and the counterfort. The counterfort itself, although usually covered entirely by the embankment, forms a triangular slab supported on two sides.

The greatest advantage of this design is that the wings are designed to act as counterforts, thereby economizing in concrete as much as is consistent with stability. Practically all other designs embodying this principle make use of the concrete tie between the lower ends of the wings. All such ties, however, when properly designed to resist horizontal shear and vertical bending moment, require considerably more concrete than the counterforts require. The ties between the wings have the additional disadvantage of making it necessary to excavate all that part of the roadbed between the ends of the wings, greatly increasing the amount of such work.

The great economy in this design over the cantilever abutment is due to the fact that stability is maintained by the general shape of the footing rather than by the width of the footing at any particular section. The advantages of this difference are many and all important. The unequalized toe and heel pressure of the cantilever is entirely done away with. As a rule, cantilever abutments require a footing as large and heavy as the corresponding gravity abutment, whereas this design requires a footing to carry the vertical loads plus a relatively small vertical resultant due to the action of the wing buttresses. Further, the abutment as a whole is designed and must act as a unit. The main wall cannot fail without lifting the wings, and the wings cannot crack away from the main wall. All reinforcing bars are placed in the outside face of the wall and therefore in the right place to receive and distribute expansion or contraction due to temperature changes.

On the basis of $10 per cubic yard for plain concrete and $15 per cubic yard for reinforced concrete this style of abutment, 10 ft. high, will cost practically the same as a gravity abutment providing for the same width of embankment and size of bridge seat, but for greater heights the saving in the reinforced design grows rapidly. At a height of 20 ft. above the top of the footing there is a saving of approximately 30%; at a height of 25 ft., a saving of 50%; and at a height of 30 ft., a saving of 90% over the cost of a gravity abutment.

FIG. 3. FRONT VIEW OF A MICHIGAN HIGHWAY DEPARTMENT BRIDGE ABUTMENT

Girders rest on cross wall, end stringers rest on back wall

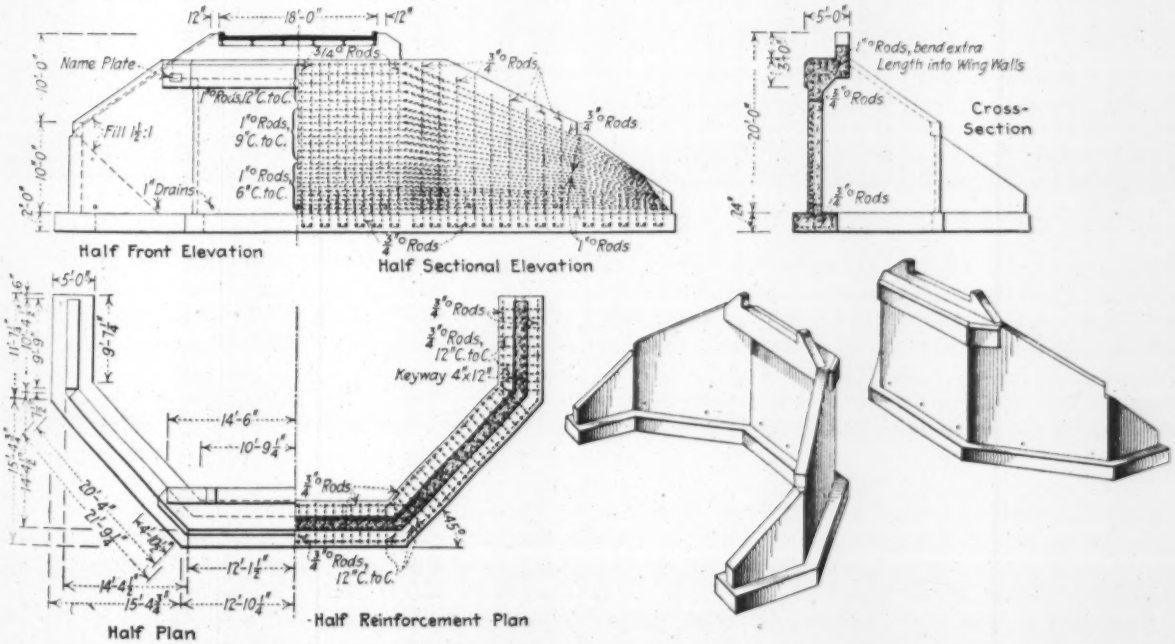


FIG. 2. ABUTMENT ADOPTED AS STANDARD BY MICHIGAN STATE HIGHWAY DEPARTMENT

The drawing reproduced is a facsimile of the 24x30-in. blueprint sent out to contractors, except that the blueprint has no figure dimensions but is provided with letter dimensions and tabulated quantities for walls varying in height from 10 to 20 ft. in increases of 1 ft. The drawing represents the abutments to carry reinforced-concrete girders. A similar drawing is prepared for abutments carrying steel girders.

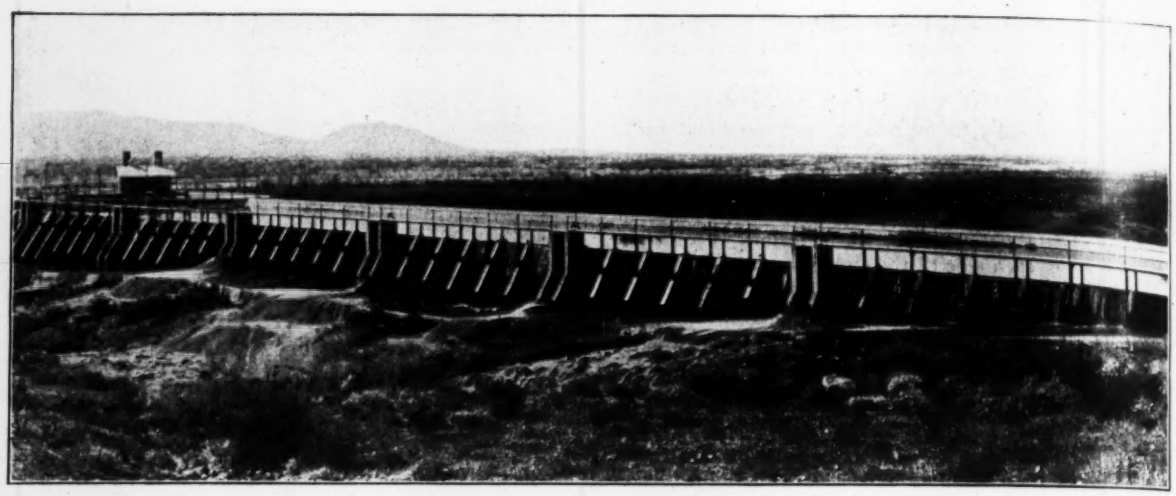


FIG. 1. SPILLWAY AT TERMINUS OF CROSS CUT CANAL

Impulse Wheels Developed for Silt-Laden Water

By J. W. Swaren*

SYNOPSIS—Utilizing a fall of 117 ft. between two irrigation canals on the Salt River Project in Arizona. Unusual combination of difficulties overcome—variable flow with heavy silt and chemical burdens, local temperature variations of 90°, etc. Large reliance necessary on reinforced-concrete structures. Butterfly valves required. New type of impulse waterwheel developed, turbines being excluded by character of water. Electrical equipment to meet needs of plant as a low-tension distributing center and a high-tension receiving and switching station.

That portion of the Salt River Project of the United States Reclamation Service on the left bank of the river lies in a series of mesas, or table lands. Each of these table lands is served by a canal with its head at or near the river and skirting the upper edge. The principal canal, the Arizona, skirts the mountains and is the main artery conveying water from Roosevelt dam for the underlying canals, as well as for the service of the first, or upper, mesa. The principal underlying canal is the Grand, with its head near the Salt River and originally about 8 mi. from the Arizona at its nearest point. Water from the Arizona Canal was conveyed to the Grand by a canal known as the Cross Cut, there being a total fall in this distance of 130 ft. A careful reconnaissance developed the interesting fact that by extending the Grand Canal up a small arroyo and cutting a new Cross Cut Canal to the east of a natural feature known as "Hole in the Rock" 117 ft. of the total fall could be concentrated in a distance of less than ½ mi.

That has been done, and a hydro-electric plant, known as the Cross Cut Station, with an installed capacity of 5,250 kv.-a., has been built at this point, 1 mi. from Tempe and 8 mi. from Phoenix. This plant is of unusual interest and importance from an engineering standpoint.

The stream flow is entirely dependent on the irrigation requirements of the land below and varies from 0 to 720 sec.-ft., the carrying capacity of Cross Cut Canal. The physical characteristics of the water are unfavorable for hydraulic apparatus, as there always is held in suspension a considerable quantity of silt; this at times reaches the full transporting capacity of the stream and is augmented by small pebbles that roll in great numbers along the bottom of the canal. The chemical characteristics are equally unfavorable, contact with iron or steel precipitating a deposit that quickly interferes with proper seating of valves or operation of wicket vanes and rapidly diminishing the area of water passages. In addition to these difficulties, climate and topography impose still other handicaps. The pipe lines are laid down a southerly slope of solid rock, where the expense of trenching is prohibitive. Temperature of the air varies from 36° to 126° F., making expansion a considerable problem.

Besides the economy of abstracting the power from the water necessarily supplied to Grand Canal, the fact that this power house is near the load center of the entire transmission system of the irrigation project makes it almost the equal of a steam auxiliary as an assurance of service. This fact was kept in view throughout the entire design, especially so in laying out the electrical switching arrangements, which were kept unusually flexible.

The forebay headgate settings, pressure pipes, power house, including all water passages and transformer houses, are constructed of reinforced concrete. Gravel was taken from the Salt River about a half-mile from the power house, washed and screened to two grades—$\frac{5}{16}$ in. and 1¼ in. respectively—and hauled by teams to the job. A 1:2:4 mixture was used throughout, except for thin slabs in the switchroom and the wash for building exteriors, where a 1:2 mixture was provided. A

*R. R. 2, Box R, Hayward, Calif.

unit mixing plant, with a ¾-yd. Cube mixer driven by a gasoline engine, handled the entire work, which is monolithic throughout. Even the switchroom slabs were poured in place. Concrete was chuted wherever possible; and as the building was designed to conform to the topography of the site, wheelbarrow transportation was required but little.

Features of Construction

Cross Cut Canal at its terminus is widened into a forebay 60 ft. wide and 300 ft. long, the static water level being elevation 1,263.95. Construction was started at the forebay and the pressure pipes built down hill, just the reverse of usual practice. While this work was in progress, the intricate and rather complicated reinforcing for the water passages was set.

The entrances to the pressure pipes are protected by trash racks of ⅜x3-in. mild-steel bars, spaced $1\frac{11}{16}$ in. On the downstream side of the trash racks are a series of sand-trap valves set in a trench extending clear across the forebay. These are cones 7 in. in diameter at the seat, opening downward and discharging into a tunnel that empties into the spillway. They are quite successful in operation and remove a large percentage of the rolling stones. Flushing is done by hand at irregular intervals, determined by the amount of material transported in the water; during storm periods flushing is continuous.

The spillway weir is on the east edge of the forebay and is 344 ft. long (see Fig. 1). The pipe-line intakes are rectangular in section, 10 ft. 6 in. high by 8 ft. wide, and are separated by a 24-in. concrete dolphin, notched for stop logs. In a space of 8 ft. these rectangular sections converge to circular sections 8 ft. in diameter. A bronze-mounted cast-iron butterfly valve, rotating on a vertical axis and with a net opening 8 ft. in diameter, is set in this section 6 ft. from its commencement.

The 8-ft. circular section extends 24 in. beyond the butterfly valve, where it again commences to taper; and in 9 ft. 6 in., at the center line of the surge tower, it has contracted to 7 ft. in diameter—the bore of the pressure pipe. The surge tower is 24 in. in diameter and only 15 ft. high, as the multi-jet tangential wheels with jet deflectors reduce all the surging to a minimum.

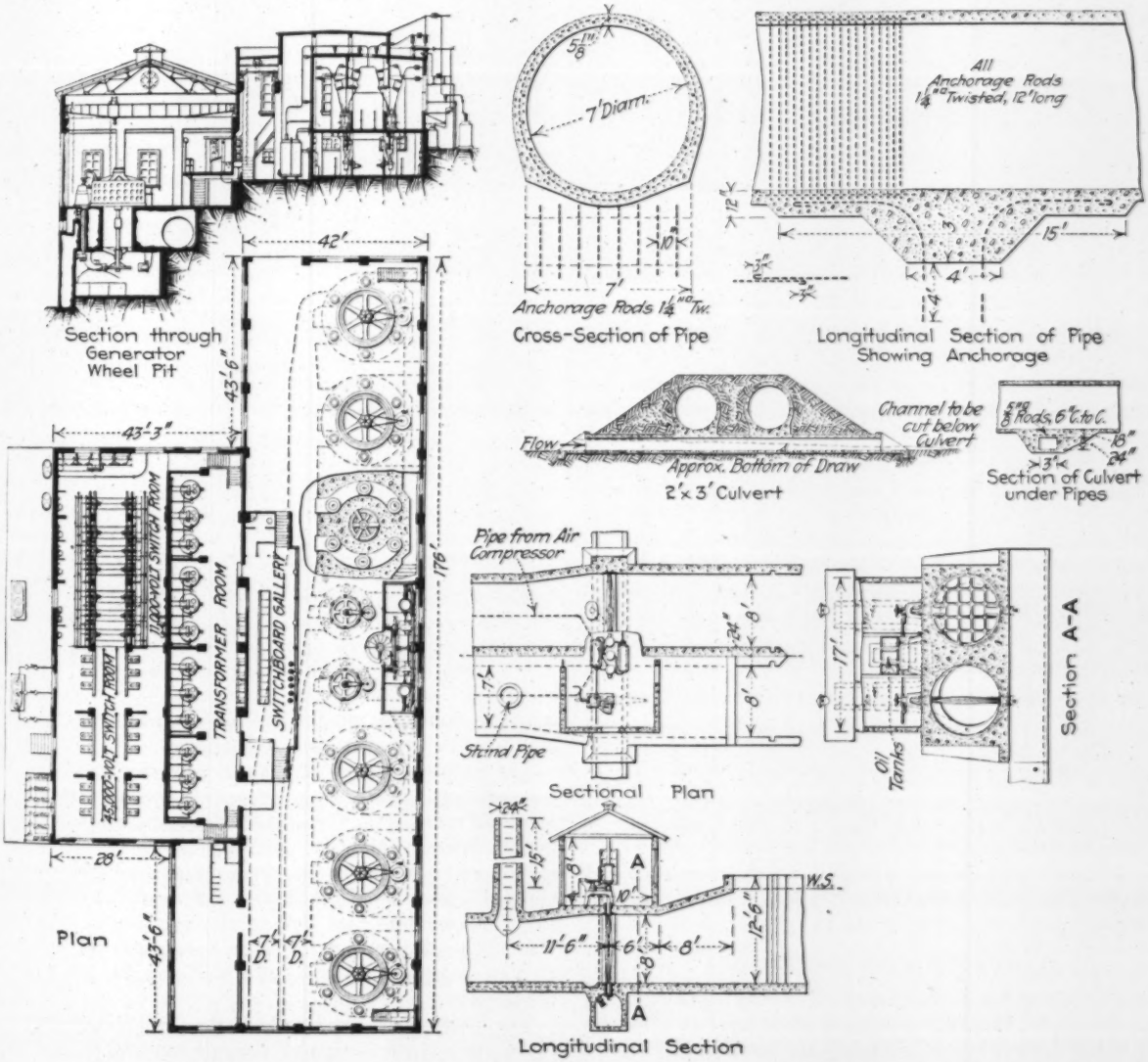


FIG. 2. PLAN AND SECTION OF STATION. DETAILS OF REINFORCED-CONCRETE PENSTOCK AND ARRANGEMENT OF BUTTERFLY GATES: CROSS CUT DEVELOPMENT

The butterfly valves are rather unusual in design. The lower trunnion and thrust bearing projects through the bottom of the conduit into a tunnel, making inspection easy. This tunnel also catches the discharge from trap valves in a sand trench on the downstream side of the valve. The upper trunnion projects through the top of the conduit into a concrete steel-roofed penthouse, 10x17 ft., which covers the operating mechanism. Normal operation is by hand. Emergency operation from the power house is provided for by 2-in. steel compressed-air lines embedded in the concrete of the pressure pipes. The air line in the east pipe controls the valve of the west line and vice versa, a precaution against pipe-line breaks.

The method of operation is unique. A piston playing in a cylinder with oil in each end moves a rack that engages a second rack on a segment of a circle mounted on the valve stem. The normal position of the gate is open, with the piston at the outer end of its travel. An oil tank is connected to the cylinder, and compressed air admitted to this tank slowly drives the piston to the outward end of its travel, forcing the oil in the operating cylinder into another tank and closing the valve. Return to normal can be accomplished by hand operation only. With a pressure of 125 lb. at the power house the gate can be closed in 40 sec.

Details of Pressure Lines

The pressure pipes, of which there are two, are designed for a maximum static pressure of 110 ft. Each is of 7-ft. internal diameter throughout its entire length; the east pipe is 2,240.44 ft. in length from the commencement of the 7-ft. section to the power-house wall; the west pipe is 2,247.34 ft. long. The steel at maximum head is never stressed higher than 14,000 lb.

The two lines are cast separately on the same monolithic base laid on the bare rock. Anchorages are frequent, nine being set. They are made by drilling two rows of holes 4 ft. deep and transverse to the main axis into the rock; 1¼-in. bars 12 ft. long are grouted into these holes and bent respectively up and down, parallel to the main axis, effectually tying the pipe to the rock face. The minimum wall thickness is 5½ in. Plain reinforcing rod is used throughout.

The longitudinal reinforcing consists of 20 rods, ¾ in. square, from the headgates until a static head of 71 ft. is reached. From there to the power house 20 rods, 1 in. square, are used. The circumferential reinforcing is of rounds set as follows:

Static Head, Ft.	Size, In.	Spacing C. to C., In.
10	½	6
14	½	5
21	½	4
32	⅝	5
43	⅝	4
48	¾	5
65	¾	4
75	¾	3½
105	⅞	4
114	⅞	3½

All pipe reinforcing has a 4-in. hot bend at each end of the rod. After completion the pipes were covered with earth.

Power Station and Wheels

The power house has three main rooms—(1) the generator room, 176x42 ft., with its floor level at elevation 1,164 and the wheel pit beneath at elevation 1,144; (2) the machine shop, 16 ft. 3 in. by 43 ft. 6 in., at the same elevation as the generator room; and (3) the transformer and switch house, 89 ft. by 43 ft. 3 in., at elevation 1,170, rising 0.75 ft. in the switchroom. The extreme height is 63 ft. on the tailrace, or west, side. The station rests on solid rock benches excavated to grade. The generator-room floor is a massive reinforced block, extended clear to the rock foundation, except where cored out for the wheel pits; but it is thoroughly honeycombed with the water passages.

The generator roof is a steel-truss structure, while the transformer- and switch-house roof is of reinforced-

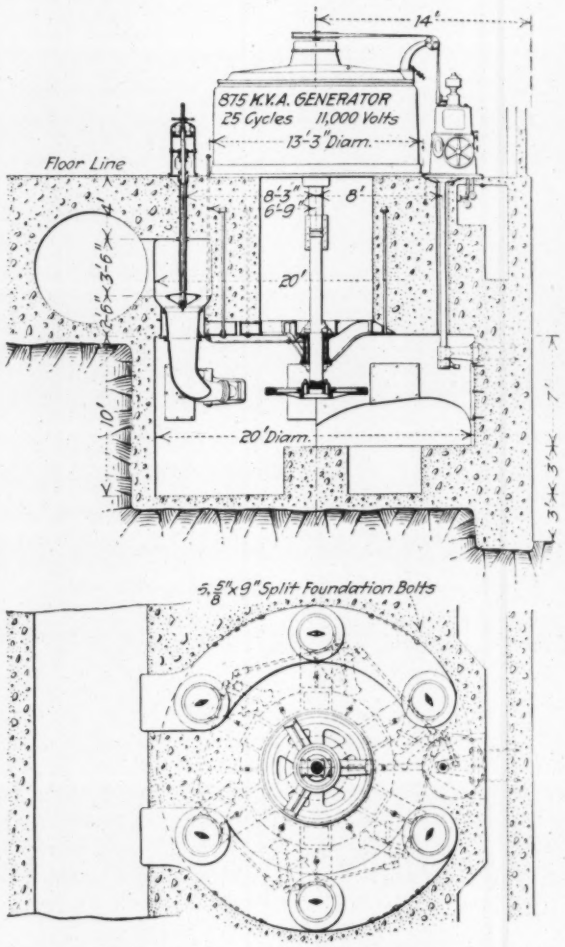


FIG. 3. DETAILS OF GENERATING UNIT

concrete slabs. A small clerestory is provided for the high-tension busbars and line entrances.

The water passages are divided into two groups, one for each pipe line. Each group consists of a tapered manifold parallel to the main axis, from which branch two distributors for each unit, embracing the shaft pit. Each manifold supplies three main units, one exciter unit and one governor oil-pump unit. Special flat bars and steel plates were used for reinforcing these passages. The steelwork is extremely complicated, and its description is impossible in the space that can be allotted to this article.

The most unusual and perhaps the chief feature of this installation is the design of the waterwheels. The total gross head available is 116.48 ft., and pipe friction was estimated to reduce this to an available head of 111 ft.,

on which assumption bids were asked, guaranteeing an efficiency of 75% from head-water to tail-water, with units of 1,000-hp. capacity and a speed suitable for direct connection to electric generators. The tender of the Pelton Water Wheel Co., San Francisco, was accepted; the mechanical conditions of the water precluded the use of a turbine, and an entirely new type of Pelton-Doble tangential wheel was developed.

The new type (see Fig. 3) consists of a vertical-shaft unit with six nozzles, set equidistant about the periphery of the runner. The moving element is designed to withstand the stresses set up when operating with any combination of nozzles from one to six. By changing the number of nozzles in use a practically straight-line efficiency curve is obtained, regardless of the amount of water passing through the power house. Minor load variations are taken care of by deflectors, one for each nozzle, all interconnected and controlled by a single governor for each unit. The nozzles are plain with renewable tips, while the deflectors are fitted with renewable edges.

The nozzle bodies are of cast steel suspended from concrete chambers cast in the water passages. Water entrance is controlled by an oil-operated poppet valve seating in the upper opening of the nozzle body. The valves controlling the piston stroke of the operating cylinder for these poppet valves are hand operated with very fine threads, so that quick opening or closing is prevented. Oil for the operating cylinder is taken from the governor oil system, described later.

The pitch line of the runner is set 3 ft. above the tail-water, to overcome interference from highest tail-water. This arrangement reduces the net head on the waterwheel to 107 ft. and requires a wheel efficiency of 80% in order to meet the guarantees exacted. It is interesting to observe that during recent storms, when the tailrace was filled with back-water, these units worked satisfactorily with a tail-water clearance of 15 in.

The buckets are a modification of the familiar Doble ellipsoidal bucket, designed to prevent flooding and stream interference by the discharge. The runner is suspended in a wheel pit 20 ft. in diameter, to which access is had through the shaft well, which is 7 ft. in diameter.

But one steady bearing is used, this being carried by a framework set in the bottom opening of the shaft wall. It is grease lubricated by a motor-driven grease pump, an individual pump for each unit being set on the power-house floor. Erection was much facilitated by a concrete pedestal 3 ft. high and 4 ft. in diameter, cast in the center of the wheel pit. The total weight of the rotating elements is carried by a Kingsbury thrust bearing mounted on top of, and supported by, the electric generator frame.

The governors are a modification of the standard Pelton-Doble oil-pressure governor. Instead of a cylinder-and-piston servometer, a pressure chamber—a segment of a cylinder with a vane rotating on a vertical shaft set at the axis of the segment—is employed. The oil admission to either side of the vane is controlled in the usual manner and by the usual mechanism, except that the inclined wedges of the over-reach and return mechanism are bent to an arc of a circle with a center coincident with the center of the vane shaft. The vane shaft projects through the power-house floor and is connected in the usual manner to the deflectors.

Oil for the governors is obtained from a central oil set, installed in duplicate, placed in a pit 10 ft. deep and with a floor area 7x27 ft. This pit is between the exciter wheel pits in the center of the building, and a pipe tunnel runs the entire length of the generator floor. A circular iron stairway leads from the power-house floor to the oil pit, while stairways at each end of the building provide access to the tunnel.

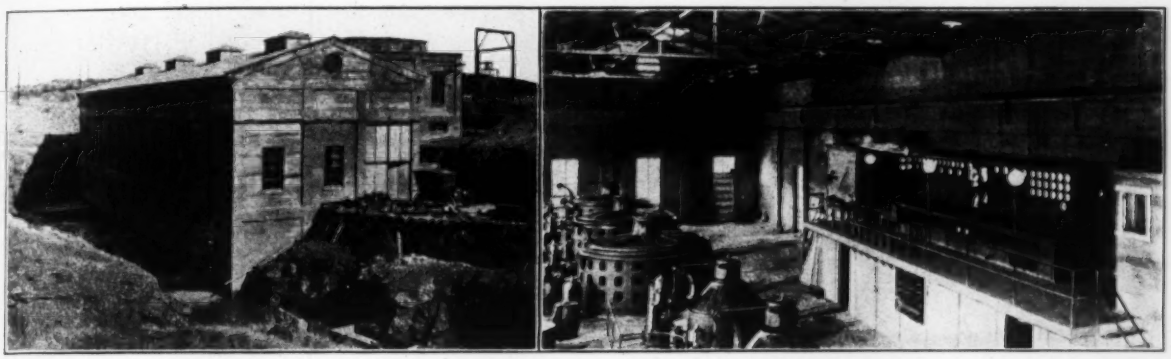


FIG. 4. CROSS CUT HYDRO-ELECTRIC STATION, EXTERIOR AND INTERIOR

Each oil set consists of a Pelton-Doble water motor carrying on the same shaft a two-stage positive-displacement rotary pump, one stage being mounted on each side of the motor runner. The motor is fitted with an oil-operated needle nozzle, with automatic control governed by the height of the oil in the pressure reservoir. Oil is drawn from steel sump tanks having a capacity of 5,000 gal., while the pressure reservoirs of each set have a capacity of 400 gal.

The oil filter for the lubricating-oil system is also set in this pit, together with a motor-driven oil pump that elevates the oil to a pressure tank set under the roof of the transformer house.

Electrical Equipment

The electric generators are Westinghouse three-phase 25-cycle 11,000-volt machines rated at 875 kv.-a. at 80% power factor, when operating at 94 r.p.m. The exciters are vertical units, driven by Pelton-Doble wheels identical in design with the larger units, and are rated at 200 kw. 125 volts, when operating at 150 r.p.m.

The generator room is spanned by a traveling crane with electric hoist, hand traverse and travel. It has a span of 39 ft. 4 in. and is rated at 40,000 lb. capacity.

The switchboard is set on a gallery and is unusually flexible, as this station is the center of distribution for a low-tension power network, a receiving station for the Arizona Falls generating station and a switching station for the 40,000-volt transmission system.

The transformer rooms and switchrooms are chiefly of interest here because of the large number of 2-in. barriers reinforced by "Steel-crete" and the 4-in. partition walls reinforced with ¾-in. riveted rods. These walls were poured monolithic.

Each oil switch is so arranged that it can be completely isolated for inspection, without service interruption, while the various groups of busbars and switches are segregated and arranged in duplicate so that extensive repairs and

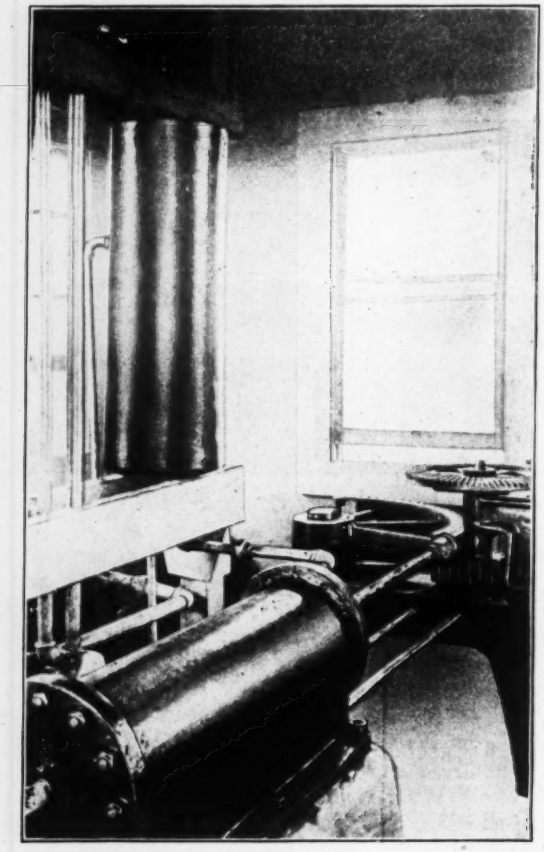


FIG. 5. EMERGENCY-CLOSING MECHANISM FOR BUTTERFLY VALVES

replacements, when necessary, can be made in perfect safety. The 10,000-volt current is carried by single-conductor cambric-insulated cables, drawn in single-duct paper conduits, which in turn are embedded in the concrete floors and walls.

Testing the Plant

The entire plant has now been in operation about 18 months. As a considerable bonus and penalty formed a part of the contract, a formal efficiency test of the wheels was made on Jan. 16, 1916, to determine the actual efficiencies.

One unit was selected for test. The load was provided in an unusual manner. The connections of one generator were reversed. This generator and the generator of the unit under test were connected to an isolated busbar. The generator reversed in direction of rotation came up to speed as a synchronous motor when the unit selected for test was started. Water was then turned into the nozzles of the motoring generator. Striking the backs of the buckets, it provided a brake capable of accurate control. It is of more than passing interest to mention that the Kingsbury thrust bearing on the motoring generator, although revolving backward and subjected to unusual thrust stresses, did not show the least indications of distress throughout the two days the tests were in progress.

A weir was built in the tailrace for measuring the water. Current meters were used for determining velocity of approach in the forebay and tailrace. Laboratory-type pressure gages were checked against the static head for determining the pressure, and there were precision instruments for measuring the electrical output, a certified factory test of the electric generators being used for determining mechanical input. After the test all the instruments, including current and potential transformers, were shipped to the Bureau of Standards, Washington, D. C., for calibration.

The test was made by a board of engineers composed of O. H. Ensign, Consulting Engineer; J. M. Gaylord, Electrical Engineer; and W. S. Cone, Project Manager, United States Reclamation Service. The final computations of this board of engineers showed an overall efficiency of 79.26%, which was in excess of the contract requirement and equivalent to a wheel efficiency of 83%. A value of $f = 0.034$ was computed in the expression for head lost by friction

$$h = f \frac{l}{d} \frac{v^2}{2g}$$

for the reinforced-concrete penstocks. As the velocity is approximately 2.6 ft. per sec. for 100 sec.-ft. flow, this value for the friction coefficient is very high.

The operating and testing crew were under the direction of E. S. McClelland, Assistant Engineer, United States Reclamation Service, while W. R. Elliott, Engineer, Salt River Water Users Association, was official observer for the purchaser. F. Gfeller and the writer were the official observers for the Pelton Water Wheel Co., contractor for the hydraulic equipment.

Kingfisher Filter Gallery and Pump House

If one were angling on an Oklahoma stream and ran across a structure like that shown in Fig. 1, he might think he was on one of the United States Government's many small "navigable" rivers and that the structure was a lighthouse. As a matter of fact it is the intake and pumping station for the water-supply of the City of Kingfisher, which has a population of about 3,000.

The tower-like structure is built over an intake well, which has leading into it an infiltration gallery extending under the bed of the stream. The building houses a 250-gal. per min. Deane triplex pump geared to a 25-hp. induction motor. The pump has extension barrels 30 ft. long. The capacity of the plant is 300,000 gal. daily. Water is pumped against a head of 225 ft. to an elevated tank about a mile distant from the pumping plant. The suction line is equipped with a bypass, to reduce the starting torque on the motor.

FIG. 1. INTAKE AND PUMP HOUSE OF THE KINGFISHER, OKLA., WATER-SUPPLY

FIG. 2. CONSTRUCTION OF INFILTRATION GALLERY

The receiving well was sunk first as an open cylinder, and the infiltration gallery was afterward cut through under the creek. The brick well casing or lining was laid on a concrete shoe or cutting edge that sank of its own weight as excavation proceeded. The bricks were laid with cement mortar, to make the whole structure water-proof. In order to prevent contamination of the receiving well by the flood waters of the creek it was necessary to carry the water-tight walls of the well some 25 ft. above the normal level of the creek, which accounts for the light-house appearance of the structure.

The top of the infiltration gallery is 15 ft. below the bottom of the creek. The method of constructing the gallery is illustrated in Fig. 2; a longitudinal section is shown in Fig. 3.

In building the gallery by open excavation in the bed of the creek permanent wooden sheet piling 3 in. thick was driven on the downstream side to bedrock. This was done not only to form the coffer-dam, but also to retard the underflow and divert it into the gallery. On the upstream side the piling was temporary and merely for construction purposes. Between the sheet piling and the wall of the gallery 2 ft. of selected gravel and sand was placed. When the construction work was completed, the upstream piling was removed, leaving only the curtain of sand and gravel.

The pumping plant is controlled from the municipal electric-light and power station a few hundred feet away, where for additional fire protection two duplex steam pumps of 750 gal. per min. capacity are kept in readiness for service. These pumps have a suction line leading directly to the receiving well on the creek, so that they are independent of the well pump.

The plant described was designed and constructed by the Benham Engineering Co., Oklahoma City, Okla. Exclusive of the pumps and fittings it cost $6,000.

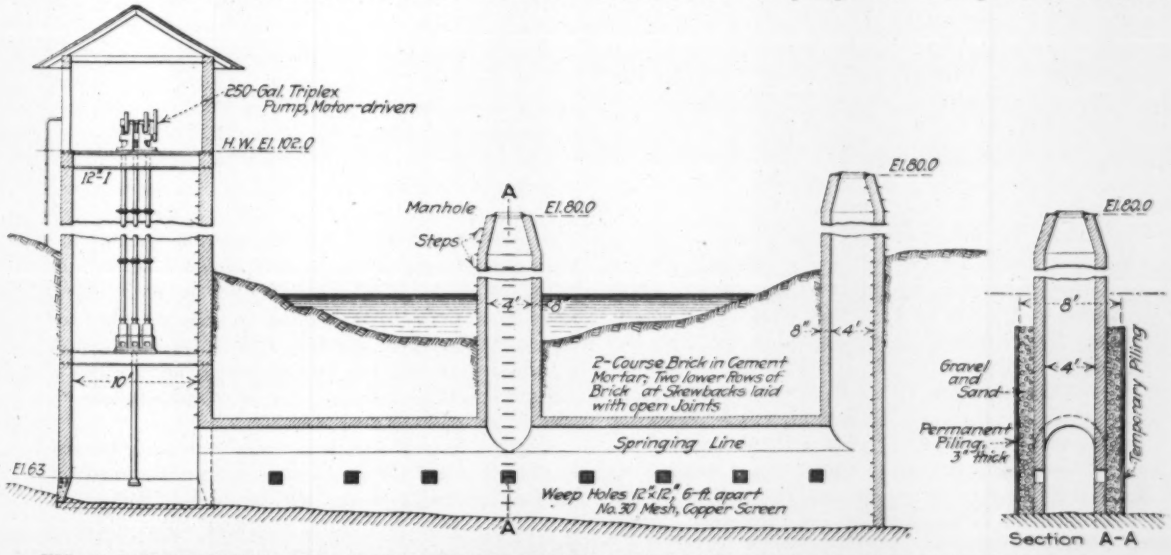


FIG. 3. LONGITUDINAL AND CROSS SECTIONS OF THE RECEIVING WELL AND INFILTRATION GALLERY, KINGFISHER WATER-SUPPLY

Engineering Literature

Materials of Construction

REVIEWED BY CLYDE T. MORRIS*

THE STRUCTURE AND PROPERTIES OF THE MORE COMMON MATERIALS OF CONSTRUCTION—By G. B. Upton, Assistant Professor of Experimental Engineering, Sibley College, Cornell University. New York: John Wiley & Sons. Cloth; 6x9 in.; pp. v + 327; 181 text illustrations $2.50 net.

This book is different from any other on the subject which has come under the observation of the writer, in that the discussion is almost entirely theoretical and that it contains no data on the results of tests. The greater part of the book is devoted to the internal structure of irons and steels, the changes of structure due to stresses, chemical composition and heat-treatments and their effects upon the desirability of the material for various purposes. There is very little space devoted to timber, one chapter to nonferrous metals and alloys and one chapter to cement and cement testing.

The book contains an excellent elementary treatment of theoretical and applied metallography, in which the language is simplified so that little previous knowledge of physical chemistry is required to understand the various changes that take place in the structure and properties of steel.

The book is divided into two parts, the first eleven chapters being on the determination of the properties of materials and the second part on the nature of materials and the control of their properties.

Chapter I is an introduction to the subject, with explanations and definitions of terms. Chapter II treats of the "General Nature of the Internal Structure of Materials and Action Under Load." Then follow in the next six chapters theoretical discussions of tension, torsion, transverse, compression and combined loadings, and their effects upon the internal structure of materials. The theoretical action of the material is illustrated by numerous drawings and typical test curves.

Chapter IX is entitled "Special Tests: Impact and Minor Tests; Hardness; and Fatigue." The special tests described include direct shear, shock, welding, bending, drifting, hardening, abrasion, etc. The discussion of fatigue is especially good, and a number of curves are given showing the effects of repeated stresses. Chapter X—on "Aging of Materials; Corrosion, Rust, Weathering, Rot and Protection Against Their Effects"—gives a rather short discussion of the subject. Electrolytic action is explained and given as the cause of all rusting and corrosion. The articles on rot, wood preserving and paints might well be expanded. Chapter XI finishes the first part of the book and treats of the "Choice of Materials, Working Stresses and Factors of Safety; Selection of Tests and Specifications." The greater part of the chapter is devoted to factors of safety, and it would seem to the writer that more specific instructions as to the selection, methods of making and interpretation of tests might well have been included. This would have greatly increased its value to the practicing engineer.

In the second part of the book Chapters XII to XVIII contain a good elementary treatment of the metallography of iron and steel, together with an instructive discussion of heat-treatments. Chapter XIX, on "Nonferrous Metals and Alloys," is devoted mostly to a treatment of brasses and bronzes, these being the most important. A short discussion of aluminum alloys and bearing metals is also given.

Chapter XX, on "Cement and Cement Testing," gives a short description of cement manufacture, concrete mixing and the usual tests of cement.

The book is designed to be used as a supplement to the usual laboratory courses in materials of construction and as such will no doubt find a wide adoption.

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Hool's Concrete Bridges

REINFORCED-CONCRETE CONSTRUCTION: Vol. III, Bridges and Culverts—Prepared in the Extension Division of the University of Wisconsin by George A. Hool, Associate Professor of Structural Engineering, assisted by Frank C. Thiessen, Instructor in Structural Engineering. With chapters by A. W. Ransome, Leslie H. Allen, William J. Titus, Albert M. Wolf, Philip Aylett and P. J. Markmann, and articles by A. C. Janni and S. W. Bowen. New York: McGraw-Hill Book Co. Cloth; 6x9 in.; pp. xxii + 688; 555 illustrations. $5 net.

The requirements of a complete exposition of reinforced concrete are constantly growing. About four years ago Prof. George A. Hool, of the University of Wisconsin, started a series of books on the subject, which in the original intention was to be complete in three volumes.

The first of these (reviewed in *Engineering News*, Oct. 17, 1912) was entitled "Fundamental Principles" and comprised 254 pages. The second, entitled "Retaining Walls and Buildings" (reviewed Dec. 18, 1913) required 666 pages. All of the rest of the subject was to be taken care of in a remaining volume, but the author has evidently found that this was impossible, for there has now appeared Vol. III, devoted only to bridges and culverts, a total of 688 pages. The treatment of such structures as remain is to be left to a fourth volume, to appear at a future time.

This third volume, like its predecessors, has been prepared with a view to its use in correspondence study courses in the extension division of the University of Wisconsin. It seems, however, that it is written with hardly so much of the correspondence nature in the mind of the author, so that even more than the previous volumes it is a valuable text and reference. In its contents and its treatment it fully comes up to the excellent standard set by its predecessors. The series, when complete, promises to be indispensable to the structural engineer.

With so large a book it is quite impossible to comment critically on all the contents. A brief statement of the subjects treated, however, will be given. Beginning with general introductory data, the first eight chapters are devoted entirely to the theoretical discussion of the arch rib. This discussion comprises the theory of deflection of

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curved beams, the elastic theory of the arch with special attention to the temperature and shrinkage stresses, the design of a typical arch rib, the use of influence lines for arch design, the design of unsymmetrical arches and a consideration of the effect of pier elasticity in the design of a series of arches. This latter subject is taken up in two forms, the first analysis being by the author on the ordinary elastic theory, and the second, by A. C. Janni, being a rather more complete discussion of Mr. Janni's already published analysis by the use of the ellipse of elasticity. The theoretical treatment, as will be noticed, is devoted entirely to the analysis of the arch rib. It is supposed that the reader or student will be able to analyze the remaining parts of an arch bridge by the methods taken up in the previous volume.

Chapter IX is devoted to the details of arch construction and is composed almost entirely of drawings and photographs. Chapter X is on construction methods, with special reference to arch construction, the general details of concrete construction having been treated in previous volumes. The section on centering is quite good from an illustrative viewpoint, although the design of the centering is lightly passed over.

Chapter XI describes three-hinged arches, their theory, design and construction, and is accompanied by the design of a typical three-hinged arch bridge.

Recognizing the current interest in the subject, the author has devoted Chapter XII to reinforced-concrete bridge patents. The subject, however, is too big for the slight treatment accorded it, so that the result is inadequate and in some cases misleading.

Chapter XIII, the longest in the book, discusses typical designs of arch bridges and is almost wholly given over to photographs and drawings, 71 pages of which appear. This is the most noteworthy section in the book. A student cannot fail to learn much about concrete bridges, if he studies the very clear drawings and the handsome photographs that are presented. This chapter ends Part I, which is devoted to arch bridges.

Part II, on slabs and girders, has five chapters and comprises a theory of the load distribution on slabs, typical designs of ordinary slab and girder bridges, discussions of continuous-girder bridges, cantilever-girder bridges and the use of reinforced concrete in steel bridges. This last chapter is practically entirely on floors and abutments.

Part III, on culverts, has four chapters and is composed mostly of the theory of culvert loads and details of specific types. Part IV, on construction plants, by A. W. Ransome, is in three sections—the measurement of the material, the mixing of the material and the transporting of the material. It is eminently practical, as is also Part V, in two chapters, on estimating, by Leslie H. Allen, of the Aberthaw Construction Co.

A unique feature of the book is Part VI, on architectural design, by William J. Titus. Engineers more and more are recognizing the necessity of an artistic appreciation of the possibility of the concrete bridge. They have in the past possibly been too disposed not to consider this feature; but the future is bright in this regard, and discussions such as this of Mr. Titus will undoubtedly aid those who have the best of intentions in æsthetic matters.

Part VII is entirely devoted to descriptions of various bridges, most of which have already been described in the technical press. The usefulness of giving so much space to this subject may be doubted. Part VIII, by Philip Aylett and T. J. Markmann, briefly and intelligently compares the details of American and European practice in reinforced-concrete work.

A review of the book would not be complete without further reference to the very great number of photographs and drawings. The former are nearly always well chosen and admirably reproduced; the latter are generally far in advance of the line-cut work in technical books.

Uptodate Text on Geodetic Surveying

REVIEWED BY JOHN F. HAYFORD*

GEODETIC SURVEYING—By Edward R. Cary, M. Am. Soc. C. E., Professor of Railroad Engineering and Geodesy, Rensselaer Polytechnic Institute. New York: John Wiley & Sons. Cloth; 5x8 in.; pp. ix + 279; 100 illustrations. $2.50 net.

The methods of geodetic surveying have been changing rapidly in the past fifteen years. Hence there is much difficulty in keeping a textbook on that subject up to date, as this book certainly is. The author has drawn largely and with good judgment upon publications by the United States Coast and Geodetic Survey both for text and for illustrations.

Reconnaissance, Base Lines, Triangulation, Computation of Triangulation, Trigonometric Leveling and Precise Leveling are covered clearly and adequately. Probably on account of a severe limit of length which the author had set for himself, his treatment of Map Projections, of Time, Longitude, Latitude and Azimuth and of the Method of Least Squares is so severely condensed as to be much less satisfactory than the remainder of the book. A convenient, short, suggestive list of books on geodetic surveying, astronomy and least squares is given.

Especially to be commended for their freshness are the parts of the volume dealing with precise leveling and the measurement of primary base lines. On each of these topics the reviewer knows of no textbook so fully up to date as this one.

It has not generally been appreciated how fully the accuracy of a triangulation depends upon the shape and character of the figures of which the triangulation scheme is made up. Even among experts there has been a general and fundamental misconception of what constitutes a strong figure in triangulation. This book gives the standard table now available for determining the strength of a given figure and such information as would enable a thorough man to use the table. It is to be regretted in this case, as in various others in the book, that the corresponding theory is not developed far enough to enable one to understand it.

It is clearly an error of judgment to give the zenith telescope method of determining latitude but a part of one paragraph in this volume, in which the method of determining time with equally large and rare instruments is allotted 15 pages. The chapter on Method of Least Squares is so severely condensed as to make it of moderate value only, a common mistake in connection with this topic. The applications of this method, as given throughout the book, are excellent. The work contains some errors of judgment, such as are inevitable in dealing with so difficult a subject.

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The positive virtues of the book so far outweigh the minor defects of the character that have been indicated here that both the teacher and the surveyor in the field applying geodetic methods will find the book satisfying as a short, well-written, well-arranged, uptodate text.

Railway-Bridge Stresses

REVIEWED BY HOWARD C. BAIRD*

LIVE-LOAD STRESSES IN RAILWAY BRIDGES, with Formulas and Tables—By George E. Beggs, Assoc. M. Am. Soc. C. E., Assistant Professor of Civil Engineering in Princeton University. New York: John Wiley & Sons. Cloth; 6x9 in.; pp. v + 123; 16 illustrations; 21 tables. $2 net.

The author treats of live-load stresses in bridges, as stated in the preface, by the combined use of influence lines and algebraic methods. Starting with a definition of influence lines and a clear explanation of their uses, the author proceeds to derive two general formulas—one for the live-load stress and one for its rate of variation—from which the position of load causing maximum stress for any member may be determined and then the amount of the stress obtained. The advantage of this method, which obviates the necessity of scaling ordinates, is apparent in the case of statically indeterminate structures or in special trusses of irregular shape.

The subject is treated quite thoroughly, and examples are worked out for the various types of simple bridge structures which, with the accompanying explanations, are valuable to the student in that they familiarize him with the method. The chief advantage of the method being in the calculation of stresses in statically indeterminate structures, it is to be regretted that no attempt is made to apply it to such structures. An example of some of the stresses in a drawspan or a fixed arch would be more valuable than some of the numerous tables which vary from each other by fixed percentages, such as those for the E-40, E-50 and E-60 Cooper loading.

When it is considered that exact moments and shears for any railway loading may be worked out analytically with little trouble, the value of even the simple formulas developed in Art. IV, for everyday designing of plate-girder spans or trusses with parallel chords, is not apparent.

The tables are quite complete; in fact, some of them, such as 4 and 5 for position of Cooper's loading for absolute maximum bending moment and end shear in girder bridges without panels, could be dispensed with as of no practical value.

Nearing on Anthracite Coal

ANTHRACITE: An Instance of Natural Resource Monopoly—By Scott Nearing, University of Toledo. Philadelphia: The John C. Winston Co. Cloth; 5x8 in.; pp. 251. $1.

Special interest attaches to this study of economic conditions and theories in the anthracite industry, because of the recent demands made by the anthracite coal workers for a large increase in wages and reduction in working hours. Professor Nearing reviews the history of the anthracite-coal business and the conflict between the respective interests of mine owners, operators, railway companies, mine workers, and consumers of coal. He holds that the mine owners and the railway companies (the two being in most cases identical), are receiving much more than their fair share of the earnings of the anthracite industry, as the result of their monopolistic control of the business and the unearned increment in the value of the property. He further claims that the efforts of a quarter of a century to control this monopolistic business by state and Federal regulation have failed, and the last sentence of his book reads as follows: "The change which seems most likely to benefit both workers and consumers is an economic reorganization that will make the community the owner and director of the anthracite field and of its administration."

One Hundred Eight Thousand Copies of Kent

THE MECHANICAL ENGINEERS' POCKET-BOOK: A Reference-Book of Rules, Tables, Data and Formulas—By William Kent, Consulting Engineer, M. Am. Soc. M. E. and Am. Inst. M. E. Ninth edition, thoroughly revised with the assistance of Robert Thurston Kent, Jun. Am. Soc. M. E., Consulting Engineer. New York: John Wiley & Sons. Flexible leather; 4x7 in.; pp. xliv + 1,526; 250 text illustrations. $5 net.

With the appearance of the ninth edition of Kent's "Pocket-book" for mechanical engineers is announced the printing of a total of 108,000 copies. When the eighth edition appeared in 1910, there was a total of 71,000 copies; there must have been some 37,000 copies disposed of in six years, and this is an evidence of marvelously sustained popularity and usefulness. In the face of such a showing, it is not to be expected that there should be any fundamental change of plan and scope or of the more general and unchanging engineering data. But there is and probably will continue to be an opportunity of revising each edition to include the latest data on materials and performances, which are ever shifting. Such improvement is, in brief, what has been done in this revision.

The mathematical tables are largely unchanged, except for square roots of fifth powers and four-place logs. The first considerable changes are evident in notes on materials, where there are late data (1914-16) on refractories, steel products, roofing, etc.—notably the tables on pipe, sheets, wire, bolts and nuts. "Strength of Materials" is not altered in its miscellaneous sections, except for the occasional insertion of a new paragraph; the big change here is in the use of new tables of Carnegie and Bethlehem structural-steel shapes. Under "Iron and Steel" are to be noted the American Foundrymen's Association chemical standards for iron castings for various services. There are new formulas and data on flow of air, flow of steam in pipes and the Hazen and Williams tables on flow of water. A new long table of coal analyses gives a direct comparison of fuels available by states. A few more data are given for design of condenser cooling towers. A very respectable addition is made of motor sizes required for machine tools and woodworking machines and of shop power requirements. The single page formerly given to electric railways—presenting only weight and power of cars and a few details of the largest locomotive—has risen to four pages, showing train-resistance formulas, stop-speed tables, common accelerations, comparisons of systems, etc. More attention has been given to modern electric lamps and the computation of illumination. This brief review by no means indicates all the work that has been done on this edition; nor does it mean that the result, happy as it is, is above and beyond all criticism.

*Consulting Engineer, 149 Broadway, New York City.

There are minor places where the highly specialized searcher will find weakness and ancient flavor—to take a single example, records of centrifugal water-works pump operation that tread closely on the heels of the best engine figures are missing.

Engineering from Many Angles

ENGINEERING AS A CAREER: A Series of Papers by Eminent Engineers—Edited by F. H. Newell, Professor of Civil Engineering, University of Illinois; Consulting Engineer, United States Reclamation Service; Director 1907-14, Chief Engineer 1902-7, and C. E. Drayer, Secretary, Cleveland Engineering Society; Engineer, New York, Chicago & St. Louis Railroad Co. New York: D. Van Nostrand Co. Cloth; 5x8 in.; pp. xii + 214. $1.

More than a score of busy experienced men, mostly engineers, have attempted to give helpful information for the benefit of youths or those responsible for youths who are attempting to size up the opportunities afforded by engineering as a life career and perchance to make a choice between the various branches of engineering. Besides the great divisions of the engineering field into civil, mechanical, electrical and the like, a considerable number of specialties in each field are considered, such as bridge, sanitary and metallurgical engineering. There is a discussion of architecture as a profession. There are also some broad reviews of engineering as a whole and of such subjects as vocational guidance.

Most of the discussions were originally published in either the Cleveland *Plain Dealer* or the *Scientific American*, and most of the writers are Cleveland men. As would be expected in such a collection of papers, there is considerable divergence of methods of treatment. Some of the authors consider their subject from the viewpoint of the boy or the parent trying to decide whether or not engineering is a desirable career, while others of the papers review the engineering field or specialty which is their subject, without much regard to what it offers to the youth. On the whole, the papers are interesting and stimulating and should be useful to many youths and parents.

Repairing Automobiles

AUTOMOBILE REPAIRING MADE EASY: A Complete Treatise Explaining Approved Methods of Repairing All Parts of All Types of Gasoline Automobiles—By Victor W. Page, author of "The Modern Gasoline Automobile." New York: The Norman W. Henley Publishing Co. Cloth; 6x9 in.; pp. 1,060; 479 illustrations. $3 net.

Because of Mr. Page's reputation as a careful writer on automobile engineering one is strongly inclined to the belief that the title this book bears was selected by the publishers rather than by the author. "Automobile Repairing Made Easy" may be a very good title to attract purchasers, but anyone with the thorough knowledge of automobile work that Mr. Page possesses knows that the proper comment on the title "Automobile Repairing Made Easy" is the comment of the old lady who saw a giraffe for the first time, "There ain't no such animal."

The present-day automobile is a marvelous piece of mechanical- and electrical-engineering design. A first-class garage repairman might be supposed to be able to understand, repair and adjust each and any part of the complicated mechanism, not only of the hundred and more cars of different makes now on the market, but also of a miscellaneous assortment of cars of an earlier vintage containing many features of design now obsolete. The proper comment again regarding this hypothetical first-class garage man is that "there ain't no such animal." One of the best evidences of the high quality of work done by the motor-car designers of the present day is that the average car gets along as well as it does in view of the poor work in repair and adjustment that is often done in the ordinary garage.

It is hardly to be expected that the poorly paid garage repairman will study this book. Those who will read and benefit by it will be the chauffeurs who look after the cars that they drive, who are generally more skillful mechanics than the garage repairmen. It will be a good investment for any motor-car owner to place a copy in the hands of his chauffeur.

The book appears to be thoroughly practical and sets forth uptodate practice in the repair and adjustment of the latest types of cars, including such recent features as wire wheels, starting systems—mechanical, pneumatic and electric—lighting systems, vacuum-feed apparatus, etc. In describing the repair of scored cylinders the author mentions filling in the score by the autogenous-welding process, but does not mention a new process by which the groove is filled, it is claimed, without subjecting the metal to heat.

Besides the chapters dealing with automobile mechanism other chapters treat of the design and equipment of repair shops for motor cars and the operations of various shop processes, such as welding, annealing, soldering, brazing. A chapter on shop kinks and a series of useful tables are also noteworthy.

A Book About Patents

INVENTIONS AND PATENTS—By Philip E. Edelman, author of "Experimental Wireless Stations," etc. New York: D. Van Nostrand Co. Cloth; 5x8 in.; pp. ix + 288. $1.50 net.

The author of this book disclaims any attempt to write a treatise upon patent law or to give to the average man instruction that will encourage him to act as his own patent attorney. His aim has been to give such information on patent matters as the average inventor or engineer or manufacturer stands in need of, without going into the technicalities of patent law.

It is a difficult matter in compiling a book of this sort to know what to put in and what to leave out. On the whole the author seems to have used good judgment in his selection of matter. Particularly commendable is his warning against a number of the fraudulent or semifraudulent practices that are common in connection with the patent business.

An appendix of some 50 pages contains brief summaries of court decisions on patent matters. However useful these may be to an attorney, it is doubtful whether the average user of this book will be able to obtain practical information from them.

United Engineering Library

ANNUAL REPORT OF THE LIBRARY BOARD, UNITED ENGINEERING SOCIETY, FOR 1915—New York (29 West 39th St.): The Society. Paper; 8x10 in.; pp. 28.

In view of the pending proposition that the American Society of Civil Engineers shall remove its headquarters and consolidate its library with the library of the other three great national engineering societies, the report of the board that carries on this library is of special interest at this time. On Dec. 31, 1915, the library contained 62,446 books and pamphlets. The total recorded number of visitors to the library in 1915 was 12,820. There were 679 requests for outside service for furnishing reference

lists, making translations and preparing photostat copies. The total cost of carrying on the library for the year was $16,380, of which about $3,000 was returned in payments made for searches, sales of duplicate books, etc. In the reading room conducted in the library 821 regularly published periodicals are received, besides a large number of other publications.

Iron and Steel Heat Treatment

REVIEWED BY F. N. SPELLER*

THE METALLOGRAPHY AND HEAT TREATMENT OF IRON AND STEEL—By Albert Sauveur, Professor of Metallurgy and Metallography in Harvard University and the Massachusetts Institute of Technology. Second edition. Cambridge, Mass.: Sauveur & Boylston. Cloth; 8x11 in.; pp. xvi + 486; 438 illustrations. $6, net.

The book named is a revised edition of the "Metallography of Iron and Steel" by the same author, which since its first issue in 1912 has become the most widely used treatise on this subject in America. The present work marks a further development in the author's contributions to metallography, both theoretical and practical, and includes many of his most important papers and lectures on this subject.

Metallography, particularly as applied to the study and control of heat-treatment, is of far more importance at the present time to the iron and steel industry than ever before. No steel-works laboratory is complete without a microscope and means for the preparation of specimens, although the use of this instrument in any particular works may be confined to a comparatively limited field. This is particularly true in the finer lines of steel products where the microscope is almost indispensable. Metallography has not taken the place of other means of investigation to any important extent, but has become a valuable aid in nearly all kinds of metallurgical work.

Professor Sauveur's treatise has been almost entirely reset and comprises 27 chapters and an appendix dealing with the nomenclature of the microscopic constituents. The work has been enlarged and unified, the chapters and pages numbered consecutively and a fairly complete index provided—all of which adds materially to the value of the work and marks quite an improvement over the previous edition. The practical portion of the subject is treated first, leaving the more complicated theoretical parts to the last few chapters. This arrangement will be of convenience to the engineer or student who is beginning the study of metallography, and tends to encourage an interest in the subject.

The general plan of treatment includes related matter of a metallurgical character dealing with the processes of manufacture in a general way, so that the reader who is unfamiliar with the metallurgy of iron and steel will be able to follow the subject intelligently. There are a few points dealing with the practical application of heat-treatment that require some modification; for instance, in regard to the heating for annealing (page 233) it will be found in annealing large quantities of soft steel under 0.10 carbon that the minimum temperature given is about 50° C. too low to secure uniform refinement of grain. However, anyone in charge of annealing operations would not be misled by this, as the work would be checked by fracture or microscopic examination without relying solely on the pyrometer readings. In this way experience would soon establish the lowest temperature at which reliable results might be obtained under shop conditions.

The practical application of metallography is now fully recognized and its field of usefulness well-defined in supplementing and checking other operations and in research work. For this reason and in view of the recent enormous expansion in the iron and steel industry in this country, there should be a wide field of use for a treatise of this kind.

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Bridge and Dam Romance with Engineer Hero and Author

WEB OF STEEL—By Cyrus Townsend Brady and Cyrus Townsend Brady, Jr., Civil Engineer. New York: Fleming H. Revell Co. Cloth; 6x8 in.; pp. 366; illustrated. $1.35 net.

Seldom do engineers attempt novel writing, however much some of them may draw on their imagination. Now and then a novelist features an engineering enterprise to give realism or movement to a story. In the book before us an engineer who has contributed to the columns of *Engineering News* more than once has collaborated with his father, who has a long list of novels to his credit, to produce a story which has an engineer for a hero and several other engineers as prominent characters, while the plot centers around the failure of a great bridge and the saving of a big dam from destruction. As might be expected, the novel affords a pleasing contrast with some others that have dealt with engineering matters.

Although the authors disclaim having described any actual structure, the main feature of the novel is closely modeled on the physical aspects of the collapse of the Quebec Bridge. On the sudden death of the designer of the bridge at the news of the disaster his son, who is the hero of the story, assumes responsibility for the failure of the bridge, although he had privately warned his father of the weakness of the compression members. This action not only ruins the professional reputation of the hero, but, with reputation lost, he foregoes the hand of the daughter of the president of the contracting bridge company. The girl and a "representative of *Engineering News*," a classmate of the hero, join forces in an attempt to prove that the hero was not responsible for the bridge and in a further attempt to trace him to the new field of action where he has gone to build up a new engineering reputation under an assumed name. They find him in the very act of saving a large dam from destruction by overtopping, but this achievement almost costs him his life. At just this moment the truth about the design of the bridge comes out, and all is well for the hero as soon as he recovers from his injuries.

After so striking and well-told an engineering accident as that of the bridge failure, no little skill was required to sustain the interest in recounting the construction and threatened loss of the dam, but this is well done.

The real editor of *Engineering News* has but two complaints to make about the story—a minor and a major one. Although he can but acknowledge with due thankfulness the part played by the special representative of the *News*, the editor mildly suggests that it was hardly fair to leave his man Rodney to contend between feelings of joy over the finding and justification of the hero and sorrow over the consequent loss of the fair Helen, whom he was ready to console after a decent interval. It really seems

as though the authors might have provided a second girl for Rodney to fall back on.

The major and really serious complaint of the editor is that the hero and the story alike are marred by leading the hero into a series of downright lies to save the reputation of his dead father at the expense of his own reputation, the happiness of the heroine and scientific truth. The hero proved to his own, but not to his father's satisfaction by the "empiric formulas of Schmidt-Chemnitz" that the lacing for the great compression member "C-10-R" was weak. He deferred to the judgment of the older man; but when the failure of the bridge demonstrated that judgment to be wrong, the hero should either have remained silent or else have been the first to make the truth known that an "empiric formula" had been verified by the most practical of tests—and the sacrifice of one hundred and fifty lives.

For Users of Instruments

METRO MANUAL: A Handbook for Engineers on Transits, Tachymeters, Theodolites, Alidades, Levels, etc. Rochester, N. Y.: Bausch & Lomb Optical Co. Leather; 4x7 in.; pp. 199; illustrated. Distributed free of charge.

A distinctly new thing presents itself to instrument-using members of the profession in this handbook. It discusses instruments with respect to precision and error. The remarkable "internal focusing" and reciprocal level-sighting arrangement brought out not long ago is explained, as are several other devices special to the firm issuing the book. Most of the matter, however, has application to all makes of instruments. Whoever uses surveying instruments will appreciate a careful reading of the book.

Four reports dealing with sewage disposal in as many cities have recently appeared. From Cleveland comes a "Report on Tests at Sewage-Testing Station," by Robert Hoffmann, Commissioner and Chief Engineer; R. Winthrop Pratt, Consulting Sanitary Engineer, and Harry B. Hommon, Chief Chemist and Bacteriologist. The Cleveland tests extended from the latter part of 1912 to the early part of 1914. An article describing the tests appeared in *Engineering News* of Feb. 13, 1913. A considerable part of the second annual report of the Sewerage Commission of Milwaukee is devoted to sewage disposal, including various experiments carried out under the direction of T. Chalkley Hatton, Chief Engineer, and William R. Copeland, Chief Chemist. From California comes the "Report of the Board of Engineers, Sewage Disposal, to the Cities of Pasadena, South Pasadena and Alhambra," submitted on Mar. 27. The board was composed of R. V. Orbison, Pasadena, president; Charles E. Hewes, Alhambra, secretary; and John MacMillan, South Pasadena—city engineers of each of the cities named. The three cities have already bought a sewage farm, and the report recommends a plan for treating sewage so as to produce a well-clarified, nonputrefiable effluent that can be used for sewage farming or that can be discharged into stream at will without producing nuisance. From the point of view just indicated the investigation is particularly interesting. The last report in the group deals with sewage disposal at Houston, Tex., and is by E. E. Sands, city engineer. The general subject of sewage disposal is reviewed, some local experiments are described, and plans are given for treating the sewage of the whole city by the activated-sludge process. It may be added that large working activated-sludge units have already been constructed at Cleveland and Milwaukee and that the Milwaukee report previously mentioned gives a considerable amount of information on activated-sludge experiments, much of which has been published in *Engineering News* during the past year.

Two additions to the series of lectures delivered at Columbia University under the Ernest Kempton Adams Fund for Physical Research have just been published, although the lectures were delivered some years ago. The earlier of these is "Eight Lectures on Theoretical Physics," by Max Planck, Professor of Theoretical Physics in the University of Berlin and Lecturer in Mathematical Physics in Columbia University for 1909; translated by A. P. Wills, Professor of Mathematical Physics in Columbia University. The other publication is entitled "Four Lectures on Mathematics," by J. Hadamard, Professor in the Collège de France and in the Ecole Polytechnique and Lecturer in Mathematics and Mathematical Physics in Columbia University for 1911. These lectures, which deal with both mathematics and physics, were taken down by Dr. A. N. Goldsmith, of the College of the City of New York, at the time of their delivery and were revised by the author in 1914. The Adams Fund Publications, now seven in number, "are distributed under the Adams Fund to many libraries and to a limited number of individuals, but may also be bought at cost from the Columbia University Press," New York City.

With the beginning of the present year the City of Asheville, N. C., began publication of the "Municipal Bulletin." The Health Department of Asheville has for a number of years past issued a live and readable bulletin. Health information is given in the new and larger pamphlets, together with interesting items regarding other departments—both current matter and brief summaries of annual reports. The attractively designed cover on each "Bulletin" bears a quotation pertinent to such a publication. The quotation for the February number is entitled, "What Is the Matter with the City?" It consists of a few sentences written by Zueblin, as follows:

> The city is alive. That is the trouble with it. It is alive and growing, hard to keep clean, hard to keep straight, hard to regulate after dark and on Sundays—all because it is so much alive.

The inside and outside of each back cover are utilized to give certain "municipal facts."

An echo of the great European War is found in a book just published under the direction of the Comité Central des Houillères de France, entitled "Quelques Idées Américaines Modernes sur la Formation des Ingénieurs," by André Rabut, a French engineer. The book is a translation of a number of extracts from Waddell and Harrington's well-known "Addresses to Engineering Students." According to J. A. L. Waddell, the story of its production is as follows:

When the book was issued, Mr. Waddell sent a complimentary copy to Charles Rabut, one of the leading engineers of France, well known not only in that country, but all over the world, because of his practical investigations in railroad work. After reading the book, Mr. Rabut sent it to his son André, who had entered the

Mining Department of the French Government. The young man was so pleased with the book that he wrote to Mr. Waddell, asking permission to translate portions of it for publication in one of the Government periodicals. Mr. Waddell agreed readily, and Mr. Rabut spent some time on the work. Just after the war started, Mr. Waddell received a letter from the translator saying that the book had been set up in type, but that on account of the war its publication would have to be deferred. He announced that he was going to the front and that he had made arrangements with his wife to make sure of the publication of the pamphlet in case of his death.

Five days after reaching the trenches he was killed, but in accordance with his wishes his widow and his father arranged for the publication, which has now been made.

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The curious and the learned, the geologist and the mathematician and also the engineer who can qualify in one or more of the respects indicated will welcome "The Strength of the Earth's Crust," a series of papers by Joseph Barrell which have been reprinted from the *Journal of Geology*, 1914 and 1915, and make up a volume of about 250 pages. (Yale Cooperative Store, New Haven, Conn., 75c., postage extra.) It will be comforting to some who tread this mundane sphere to be assured, in the language of "L. V. P.," who reviews the papers in the *American Journal of Science* for December, 1915, that:

> The author finds that the crust is very strong when measured by its capacity to support great deltas, mountain ranges or large internal loads due to variations in density not in accord with topography, while on the other hand the altitudes of the continents as a whole or in large sections show nearly perfect isostasy. The maintenance of such isostatic conditions through geologic time, in spite of opposing geologic activities, is held to imply the existence of a zone of undertow below the zone of compensation, which is both thick and weak to shearing stresses. Geologically such a zone, called the asthenosphere—the shell of weakness—must have important bearings, which are treated in the later portions of the work.

Engineering News ventures to express the hope that the condition of "nearly perfect isostasy" established by the author will offset any feeling of apprehension caused by the disclosure of the shearing-stress weaknesses in the asthenosphere.

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Memoirs of the late Alfred Noble have recently been published by both the American Society of Civil Engineers and the Western Society of Engineers. The care taken in the preparation of these memorial biographies, as well as the wide circle from which the tributes they contain were gathered, is worthy of the unique position Mr. Noble held in the American engineering profession. It would be difficult to name an engineer, for a generation past, who has won the esteem and affection of the profession as a whole as did Alfred Noble. Many of Mr. Noble's friends and associates outside the membership of these societies will appreciate the work that has been done and will doubtless be glad to obtain copies.

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Promises of books to be held for shipment until the close of the war are desired by the Belgium Scholarship Committee, 309 Wilkins Building, Washington, D. C. The appeal is being made primarily to American libraries, other educational institutions and learned societies. Sets of publications of the latter are desired. The request for books and also for a fund for the reconstruction of Belgium, especially in the educational field, is being made by the committee named, which includes among its members the presidents of a number of leading American colleges and universities. Richard C. Maclaurin, President of the Massachusetts Institute of Technology, is one of the college presidents on the list. There are also a number of engineers on the committee, of which Nevil M. Hopkins, electrical engineer, is chairman. Dr. George Sarton, of the University of Ghent, Belgium, is secretary of the committee, with offices in Washington at the address already given.

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Many facts and figures assembled under the caption "Methods and Costs of Collecting and Disposing of Garbage in Cities" have been printed as Report No. 52 of the State Bureau of Municipal Information of the New York State Conference of Mayors and Other City Officials. (W. P. Capes, Director, Albany, N. Y.) Various systems of garbage collection and disposal are described, and information is given as to disposal in different cities. In addition to the text the report contains two large folding tables: (1) "Methods and Costs of Collection" and (2) "Methods of Disposal." The statistical and descriptive information given is by no means confined to cities of New York State.

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"Variations in Precipitation as Affecting Water-Works Engineering," by Carl P. Birkinbine, together with discussion by various engineers, occupies more than 100 pages of the *Journal* of the American Water-Works Association for March, 1916 (47 State St., Troy, N. Y.). A group of papers on water filtration and related subjects fill some 70 pages additional, besides which other topics are treated.

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Among the recent bulletins of the Bureau of Municipal Research (261 Broadway, New York City) mention may be made of "Legal Right of Civil Service in the City of New York" ($1); "Standardization of Public Employment" (two numbers, $1 each), relating to both New York State and City, and "Training for Municipal Service" (50c.), the latter also relating chiefly to New York City.

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A valuable study of street-cleaning costs in Milwaukee has been published by the local Bureau of Municipal Research (Prof. John C. Davis, Director) under the blind title, "Efficiency and Economy in Municipal Work by Modern Type of Equipment." Squeegeeing, flushing, sprinkling, rotary brooms and pick-up sweepers are reviewed

NEW PUBLICATIONS

[So far as possible the name of each publisher of books or pamphlets listed in these columns is given in each entry. If the book or pamphlet is for sale and the price is known by the editor, the price is stated in each entry. Where no price is given it does not necessarily follow that the book or pamphlet can be obtained without cost. Many, but not all, of the pamphlets, however, can be secured without cost, at least by inclosing postage. Persons who are in doubt as to the means to be pursued to obtain copies of the publications listed in these columns should apply for information to the stated publisher, or in case of books or papers privately printed, then to the author or other person indicated in the notice.]

AMERICAN ELECTRIC RAILWAY ENGINEERING ASSOCIATION: Proceedings of Annual Convention held in San Francisco, Oct. 4-8, 1915—New York City (8 West 40th St.): E. B. Burritt, Secretary. Cloth; 6x9 in.; pp. 623; illustrated.

THE AMERICAN ROAD: A Non-Engineering Manual for Practical Road Builders—By James I. Tucker, Professor of Civil Engineering, University of Oklahoma, and Consulting State Engineer, Oklahoma Department of Highways. Norman, Okla.: Publishers, "The American Road." Cloth; 5x8 in.; pp. x + 235; illustrated. $1.08 by mail. Sold by booksellers and publishers.

THE AMERICAN YEAR BOOK: A Record of Events and Progress, 1915—Edited by Francis G. Wickware, with Cooperation of a Supervisory Board Representing National Learned Societies. New York: D. Appleton & Co. Cloth; 5x8 in.; pp. 862. $3.50.

ANNUAL REPORT OF THE HIGHWAYS DIVISION OF THE DEPARTMENT OF PUBLIC WORKS AND MINES, PROVINCE OF NOVA SCOTIA, and of the Larger Bridges and Subsidized Railways for the Year Ended Sept. 30, 1915—By Hiram Donkin, Road Commissioner and Provincial Engineer, Halifax, N. S. Paper; 7x10 in.; pp. 62; illustrated.

ANNUAL REPORT OF WATER RIGHTS BRANCH, DEPARTMENT OF LANDS OF BRITISH COLUMBIA, FOR 1915—Victoria, B. C. Paper; 7x10 in.; pp. 56; illustrated.

ANNUAL REPORT OF WATER-SUPPLY, SEWERAGE AND DRAINAGE DEPARTMENT OF WESTERN AUSTRALIA FOR 1914-15—Perth, Western Australia. Paper; 8x13 in.; pp. 109; illustrated.

BULLETINS, UNITED STATES DEPARTMENT OF AGRICULTURE—Washington, D. C. Paper; 6x9 in.; illustrated.
No. 314, Methods for the Examination of Bituminous Road Materials—By Prevost Hubbard, Chemical Engineer, and Charles S. Reeve, Chemist. Pp. 48.
No. 347, Methods for the Determination of the Physical Properties of Roadbuilding Rock—By Frank H. Jackson, Jr., Assistant Testing Engineer. Pp. 28.

THE CIVIL-SERVICE LAW AND RULES AND REGULATIONS FOR THE CLASSIFIED SERVICE (State of New York) as Amended to Feb. 8, 1916—Albany, N. Y.: John C. Birdseye, Secretary, State Civil Service Commission. Paper; 6x9 in.; pp. 92.

COAL: ITS ECONOMICAL AND SMOKELESS COMBUSTION—By James F. Cosgrove. Philadelphia, Penn. (357 West Duval St., Germantown): Technical-Book Publishing Co. Cloth; 6x9 in.; pp. 273; 33 illustrations. $3.

THE DIESEL ENGINE IN PRACTICE—By J. E. Megson and H. S. Jones. San Francisco: Technical Publishing Co. Flexible leather; 4x7 in.; pp. 136; 36 illustrations. $2.

ELECTRICAL ENGINEERING FIRST COURSE—By Ernst Julius Berg, Professor of Electrical Engineering, and Walter Lyman Upson, Associate Professor of Electrical Engineering, Union College, Schenectady, N. Y. New York: McGraw-Hill Book Co. Cloth; 6x9 in.; pp. xii + 416; 296 illustrations. $4 net.

FLOOD CONTROL AND RECLAMATION IN CALIFORNIA—By V. S. McClatchy, President, State Reclamation Board of California. [Paper presented at Annual Meeting of the National Drainage Congress at Cairo, Ill., Jan. 20, 1916.] Sacramento, Calif.: The Board. Paper; 6x9 in.; pp. 8; map illustrating Sacramento River Flood Control Project.

GEOLOGIC ATLAS OF THE UNITED STATES—Washington, D. C.: United States Geological Survey. Stiff paper; 17x22 in.; illustrated. 25c. each. Folios Nos. 195, Belleville and Breese (Illinois), pp. 13; 196, Phillipsburg (Montana), pp. 25; 197, Columbus (Ohio), pp. 15; 198, Castle Rock (Colorado), pp. 13.

GOOD-ROADS BULLETIN FOR ILLINOIS PUBLIC SCHOOLS—Edited by James H. Green and Ira O. Baker, Members of the Faculty of the University of Illinois. Springfield, Ill.: Francis G. Blair, State Superintendent of Public Instruction. Paper; 6x9 in.; pp. 32; illustrated.

IRRIGATION MANAGEMENT: The Operation, Maintenance and Betterment of Works for Bringing Water to Agricultural Lands—By Frederick Haynes Newell, Professor of Civil Engineering, University of Illinois; former Director, United States Reclamation Service. New York: D. Appleton & Co. Cloth; 5x8 in.; pp. xi + 306; illustrated. $2 net.

LATHE DESIGN, CONSTRUCTION AND OPERATION, with Practical Examples of Lathe Work—By Oscar E. Perrigo, author of "Modern Machine-Shop Construction, Equipment and Management," "Change-Gear Devices," etc. Revised and enlarged edition. New York: Norman W. Henley Publishing Co. Cloth; 6x9 in.; pp. 469; 350 illustrations. $2.50.

THE METALLOGRAPHY OF STEEL AND CAST IRON—By Henry Marion Howe, Professor Emeritus of Metallurgy in Columbia University. New York: McGraw-Hill Book Co. Cloth; 7x11 in.; pp. xxviii + 641; 123 text illustrations, 45 plates. $10 net.

THE METALLURGISTS' AND CHEMISTS' HANDBOOK: A Reference Book of Tables and Data for the Student and Metallurgist—Compiled by Donald M. Liddell, Consulting Metallurgical Engineer and Sometime Managing Editor of "The Engineering and Mining Journal." New York: McGraw-Hill Book Co. Flexible leather; 4x7 in.; pp. vii + 603. $4 net.

MODERN STARTING, LIGHTING AND IGNITION SYSTEMS: A Complete Exposition Explaining All Forms of Electrical Ignition Systems Used with Internal-Combustion Engines of All Types—By Victor W. Page, author of "Automobile Repairing Made Easy," etc. New York: Norman W. Henley Publishing Co. Cloth; 5x8 in.; pp. 509; 295 illustrations. $1.50.

THE PREVENTION AND CONTROL OF EROSION IN NORTH CAROLINA, WITH SPECIAL REFERENCE TO TERRACING—By F. R. Baker, Assistant Drainage Engineer. Raleigh, N. C.: North Carolina Agricultural Experiment Station. Bulletin 236. Paper; 6x9 in.; pp. 27; illustrated.

THE PROBLEM OF CITY BEAUTIFICATION AS OBSERVED IN EUROPE—By George T. Hammond, M. Am. Soc. C. E. [Reprinted from the Twentieth Annual Report, American Scenic and Historic Preservation Society.] Brooklyn, N. Y. (215 Montague St.): The Author. Paper; 6x9 in.; pp. 42; illustrated.

PUBLICATIONS OF THE UNITED STATES BUREAU OF MINES—Washington, D. C. Paper; 6x9 in.; illustrated.
Miners' Circular No. 20, How a Miner Can Avoid Some Dangerous Diseases—By A. J. Lanza, Passed Assistant Surgeon, United States Public Health Service, and Joseph H. White, Sanitary Engineer, Bureau of Mines. Pp. 26. Bulletin No. 89, Economic Methods of Utilizing Western Lignites—By E. J. Babcock. Pp. 73.

PUBLICATIONS OF THE UNITED STATES BUREAU OF STANDARDS—Washington, D. C. Paper; 7x10 in.
Circular No. 14, Analyzed Irons and Steels—Methods of Analysis. Pp. 17. Scientific Paper No. 272, Correlation of the Magnetic and Mechanical Properties of Steel—By Charles W. Burrows, Associate Physicist. Pp. 38; illustrated.

RAILWAY MONOPOLY AND RATE REGULATION—By Robert James McFall, Sometime Fellow in Economics in Columbia University and Instructor in Economics in the University of Minnesota. ["Studies in History, Economics and Public Law," edited by the Faculty of Political Science of Columbia University. Whole No. 164.] New York: Columbia University; Longmans, Green & Co. Paper; 6x10 in.; pp. 223.

REPORT OF THE CHIEF ENGINEER OF THE MIAMI CONSERVANCY DISTRICT (STATE OF OHIO): Submitting a Plan for the Protection of the District from Flood Damage—Dayton, Ohio: Ezra M. Kuhns, Secretary. In Three Volumes. Paper; 6x9 in.; pp. 189, 269 and 130; illustrated. Accompanied by two volumes of exhibits containing 408 drawings. Vols. I, II and III, 25c. each.

REPORT ON THE RIVERS AND LAKES COMMISSION OF ILLINOIS ON THE ILLINOIS RIVER AND ITS BOTTOM LANDS, with Reference to the Conservation of Agriculture and Fisheries and the Control of Floods—By John W. Alvord and Charles B. Burdick, Consulting Engineers. Chicago, Ill. (905 State Building): Charles Christmann, Secretary of Commission. Cloth; 6x9 in.; pp. 141; illustrated.

A REPORT ON BILLBOARD ADVERTISING IN SPRINGFIELD—Springfield, Mass.: City Planning Commission. Paper; 7x10 in.; pp. 13; illustrated.

REPORTS OF THE BOARD OF PUBLIC UTILITY COMMISSIONERS OF THE STATE OF NEW JERSEY—Vol. II, June, 1913, to May, 1914. Vol. III, May, 1914, to July, 1915. Trenton, N. J.: Alfred N. Barber, Secretary of the Board. Cloth; 6x9 in.; pp. 553 and 570.

ROAD DUST PREVENTIVES: References to Books and Magazine Articles—Pittsburgh, Penn.: Carnegie Library. Paper; 6x9 in.; pp. 39.

ROADS: THEIR INFLUENCE UPON ECONOMIC AND SOCIAL CONDITIONS—By S. M. Williams. Lima, Ohio: The Garford Motor Truck Co. Paper; 6x9 in.; pp. 16; illustrated. Text and pictorial arguments for good roads.

SPECIAL BULLETINS, NEW YORK STATE DEPARTMENT OF LABOR—Albany, N. Y.: Bureau of Statistics and Information. Paper; 6x9 in.
No. 75, Statistics of Industrial Accidents, 1914. Pp. 77.
No. 76, European Regulations for Prevention of Occupational Diseases. Pp. 77.

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Field and Office

Traveling Drag-Line Excavator

The traveling excavator shown in Fig. 1 was designed especially for ditch work, but is used also in general grading and gravel-pit work and has the particular advantage that it can be employed in handling pipe, backfilling trenches and leveling fills or spoil banks.

The frame is of steel beams and is ordinarily 24x30 ft., but the width varies from 12 to 40 ft. The greater widths are for machines that straddle ditch or other excavations. The frame is mounted on four wheels of 5-ft. diameter, having tires 3 ft. wide. At the front end are a steel truss to carry the load of the machinery and a steel A-frame supporting the steel boom, which is 50 ft. long and built of a pair of channels connected by bracing and stiffened by truss rods. Power is furnished by a Heer 40-hp. gasoline (or kerosene) engine. The weight of the ordinary machine in working order is about 13 tons.

The bucket, Fig. 2, is of 5/8-yd. capacity and of the front-dumping type. It is journaled in a bail to which

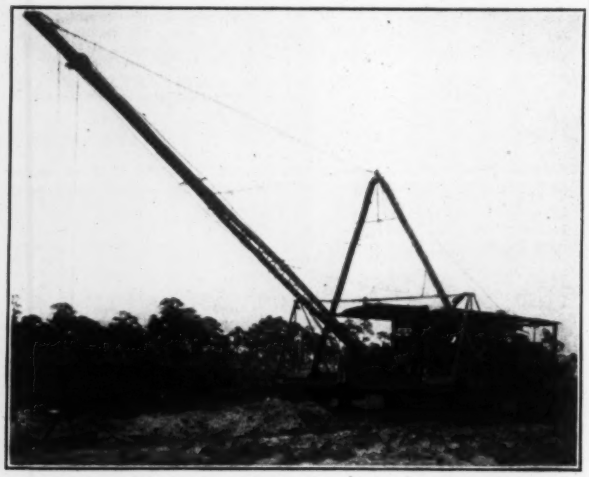


FIG. 1. DRAG-LINE EXCAVATOR AND BACKFILLER

the hoisting tackle is attached. The mouth has a long hauling bail to which the drag line is joined. The dump line is led from this bail over a small pulley in the hoisting bail to a stirrup with legs fastened to the sides of the bucket. When the drag line is slackened, the bucket overhauls the dump line and swings to a vertical position in the bail, thus discharging its entire load and delivering it directly beneath the bucket.

The machine can dig a trench 1 to 3½ ft. wide, a special bucket being used for the narrow pipe trenches. It can cut to a width of 30 ft. and a depth of over 20 ft. For handling pipe or drain tile a pipe hook is added to the hoisting block, thus facilitating the work where large and heavy pipe is being laid. The spoil is delivered on one side of the trench, leaving the other side open for distributing pipe, etc. For backfilling, the machine travels along this open side, and the bucket scrapes the

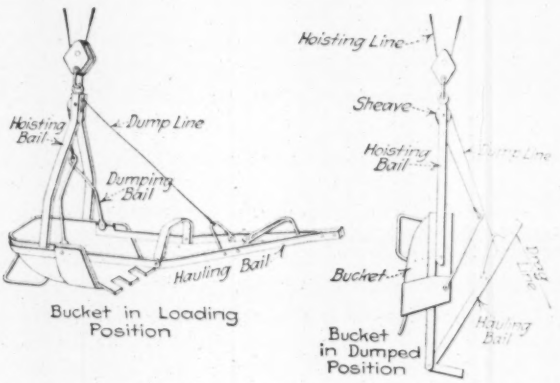


FIG. 2. BUCKET FOR DRAG-LINE EXCAVATOR.

spoil into the trench or ditch. In this work the loaded bucket is not hoisted, but is simply hauled in like a scraper.

Only two men are required—one to control all movements and the other for general work around the machine. On tile work there will be also a pipe layer (in the trench) and his helper. The weight of the ordinary machine is about 13 tons. This excavator is built by the Economy Excavator Co., Iowa Falls, Iowa.

One-Man Backfilling Machine

A backfilling machine that is operated by power and controlled entirely by one man is shown in the accompanying views. It is of the dragline type, handling a scraper which pushes the earth forward instead of lifting it. The general view, Fig. 1, shows the scraper moved partly through the spoil bank. Fig. 2 illustrates the scraper, which has a horizontal portion only long enough to get a hold in the material as it starts its forward movement. This scraper is 4 ft. wide and has a steel frame with a panel of oak planking.

The machine has a steel underframe mounted on wide-tired wheels. The front, or steering, wheels are 24 in.

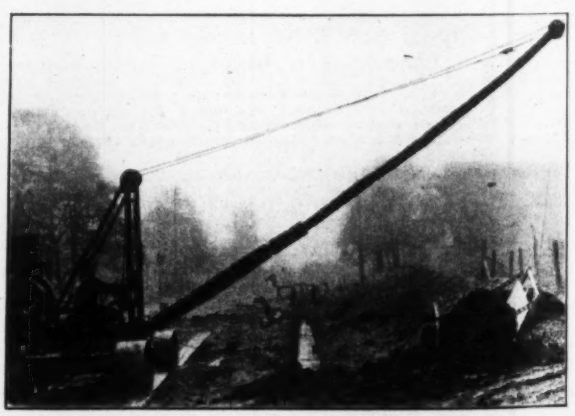


FIG. 1. ONE-MAN BACKFILLER AT WORK ON A TRENCH

in diameter and 12 in. wide, carried by an axle of two 5-in. channels. This axle is pivoted to permit vertical and horizontal movement, thus giving the machine a three-point support on rough ground. The rear, or driving, wheels are 30 in. in diameter and 18 in. wide, on an axle that is driven by a sprocket chain. A pair of transverse A-frames support the sheaves for the boom topping-lift and the hoisting cable of the scraper.

The boom is adjustable in length. The heel end is 10 ft. long and V-shaped, composed of a pair of 5-in. channels with crossbracing, and is pivoted to the main frame. Three extension pieces 5 ft. long, one of which carries the end sheaves, provides for lengths of 15, 20 and 25 ft., according to the desired reach. The full length is shown in Fig. 1. The topping-lift is led to a hand winch on the A-frame.

Power is furnished by a single-cylinder gasoline engine of 10 hp. or a two-cylinder 15-hp. engine, with roller-chain drive to an intermediate shaft geared to the two drumshafts, which are connected to the drums by clutches of the internal expanding-ring type. The cables

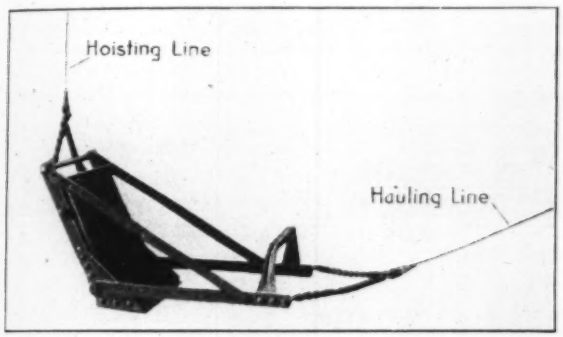


FIG. 2. SCRAPER FOR BACKFILLING MACHINE

are ⅜ in. in diameter, with a 10-in. drum for the hoisting line and a 15-in. drum for the hauling line. The intermediate shaft is connected by bevel gears to a propelling shaft having a sprocket wheel for the chain that drives the rear axle. The maximum speed of travel is nearly 2 mi. per hr. The steering mechanism is operated by worm gearing, with chains to the front axle.

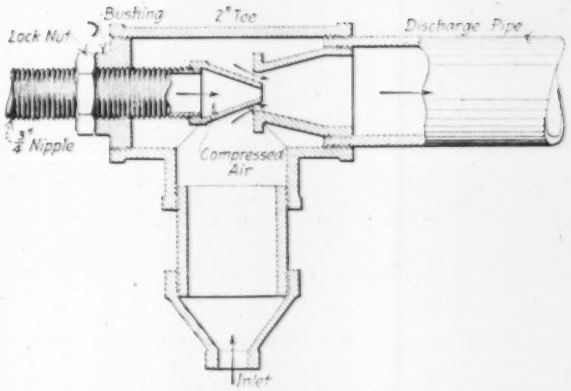
The backfiller has a wheelbase of 8 ft., a width of 7 ft. 4 in. over the wheels and a height of 9 ft. 8 in. over the A-frames. Its weight is about 5 tons. This machine is built by Pawling & Harnischfeger, Milwaukee, Wis.

Cleaning Large Gas Retorts with an Air Siphon

By H. C. McDermid*

An unusual method was employed recently to remove brick dust and chips from a large bank of gas retorts. The device used was a roughly built vacuum cleaner operated by compressed air. As the diagram shows, it was made of a 2-in. tee with a portable bushing and ¾-in. pipe screwed in one end. The nipple on this pipe was threaded over its entire length of 6 in. and was drawn down to a small opening. This small end was reamed out to a smooth finish by a taper reamer, leaving an outlet about ¼ in. in diameter. When its proper position had been determined, this pipe was secured by a locknut.

*728 Main St., Worcester, Mass.



HOME-MADE AIR SIPHON FOR CLEANING OBJECTS

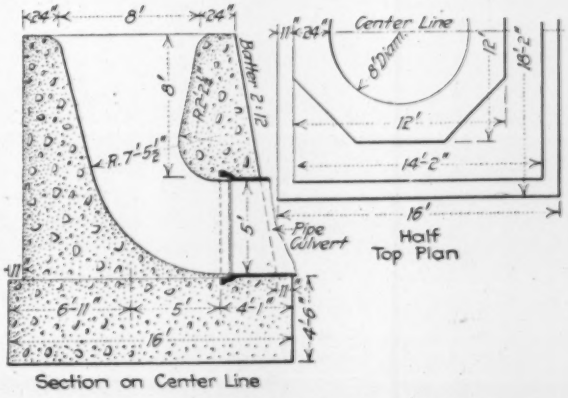
At the opposite end of the tee a short 2-in. nipple was screwed in place, its inner end forming an orifice with inside diameter of 1 in. and about 1 in. from the end, as shown. To the branch of the tee was screwed a short 2-in. nipple having a ¼-in. opening. The device is really an air siphon.

In practice the discharge pipe was used as a handle, its outer end being covered by a wet sack for collecting dust and flying chips. The collector pipe was 25 ft. long and for easy handling was balanced on a roller carried on a frame set in the mouth of the retort. The device was extremely satisfactory on the work upon which it was employed.

Spillway Culverts

Streams passing under railway embankments are utilized in some instances as a source of supply for water stations. In such cases the supply can be improved by forming a pond or small reservoir on the upstream side. To provide for this the culvert is constructed with a vertical leg or receiving end, having its top at the desired elevation of the pool. Several such spillway culverts have been built on the Chicago & Eastern Illinois R.R. (L. C. Hartley, Chief Engineer).

The drawing shows one at Johnston City, Ill. The pipe culvert proper is 5 ft. in diameter, ending in a vertical extension or receiving portion of concrete. This is octagonal in form, 8 ft. high above the top of the pipe and has a funnel-shaped opening with its top or spillway



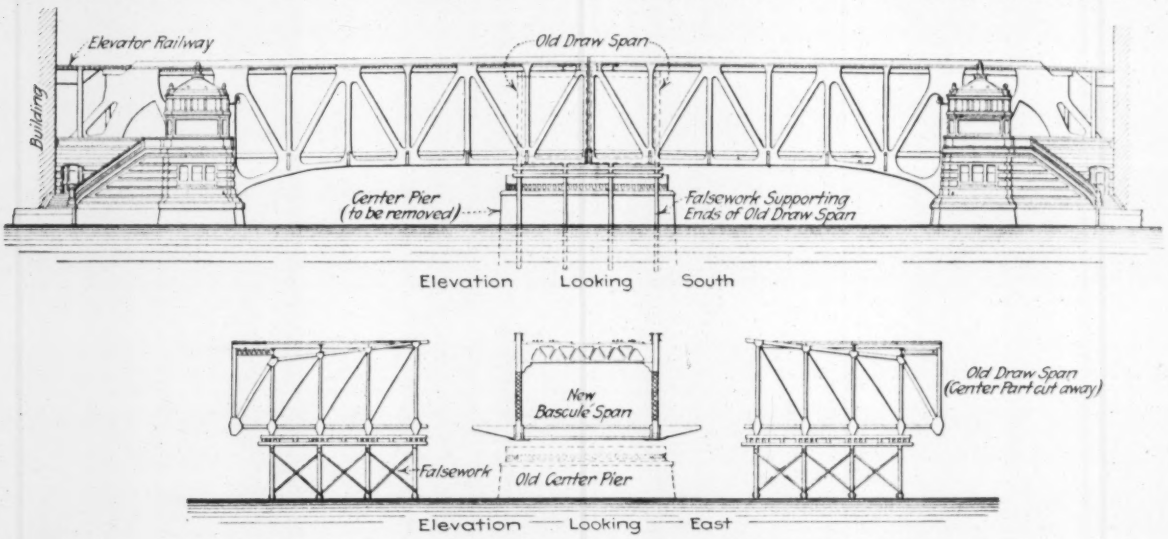
SPILLWAY CULVERT FORMING POOL FOR WATER STATION: CHICAGO & EASTERN ILLINOIS R.R.

at the desired pool level. This vertical extension has a rectangular base that also supports the end of the pipe culvert. The spillway contains 123 cu.yd. of concrete.

Putting a Bascule Bridge Into Service

The new double-deck bascule bridge over the Chicago River at Lake St. was opened for use on Mar. 4. Traffic on the elevated railway was stopped for six days while the old swingbridge was removed and the final work done on the new bridge.

The latter is of the trunnion bascule type, with a span of 245 ft. c. to c. of trunnions and a clear channel width of 209 ft. 3 in. It carries a 38-ft. roadway and two 12½-ft. sidewalks on the lower deck and the double-track line of the Chicago & Oak Park Elevated Ry. on the upper deck. It was described fully in *Engineering News*, Nov. 4 and 11, 1915. The new structure was erected in the open position, the old swingbridge being left in place to carry the elevated railway. For this purpose the deck framing in the end panels was omitted during construction, so that trains could pass through the raised leaves. The street was closed to traffic.



OLD AND NEW DOUBLE-DECK BRIDGES OVER THE CHICAGO RIVER AT LAKE ST.
The new bascule bridge is shown in position, and the middle portion of the old swingbridge cut away to make room for it

The passage of elevated-railway trains over the old swing span was stopped at 12:15 a.m., Feb. 27 (Sunday), and the removal of the tracks was commenced. At 6:22 a.m. this work was completed, and the span was swung into the open, or river, position, being blocked up on falsework already in place. The removal of that part of the old span that interfered with the lowering of the leaves of the new bridge was commenced at 6:30 a.m.

The old span was cut away in sections by oxyacetylene torches, and the material was handled by a floating derrick lying alongside. At the close of Monday, Feb. 28, the central part of the old span was practically all removed. The remainder of this span was taken down in a more leisurely manner, and the work was completed Mar. 4.

One panel of the elevated structure on each side of the river was replaced with new steelwork. The erection of the floor-beams, stringers, etc., in the two panels omitted from the new bridge leaves to allow the passage of elevated trains (during the construction of the leaves in a raised position) was commenced at 10:30 a.m. The viaduct west of the bridge was moved south about 5 ft. on Sunday, to allow the construction of the north half of the viaduct, without interruption to elevated traffic. An additional track was placed on the south half, to provide double tracks for elevated service.

The east leaf of the new bridge was moved for the first time at 4:10 p.m. Monday, Feb. 28. The leaf was operated forward and back, and small interferences in the structure were taken care of. These adjustments continued until about 6:20 p.m. This leaf was lowered to a horizontal position at 1:10 p.m., Feb. 29. The placing of the elevated tracks and switches on the east side of the river was at once commenced and continued during the night. The west leaf was moved for the first time at 8:55 a.m., Mar. 1, and after the elimination of a trifling interference in the steelwork this leaf was lowered to a horizontal position at 10:45 p.m.

Owing to unfavorable weather conditions the elevated railway did not work continuously on the track. On Mar. 4 (Saturday) at 12:33 p.m. a special car was run across the new bridge, and at 3:07 p.m. the elevated railway resumed its regular schedule. Information about this work has been furnished by Thomas G. Pihlfeldt, Engineer of Bridges and Harbor.

Loads from Moving Crowds

New experiments on the weight of crowds were recently made because of prior contradictory figures and arguments on the subject. Observations and tests have been reported with loads ranging from 20 to 25 lb. per sq.ft. for a crowd in motion to considerably over 150 lb. per sq.ft. for a packed stationary crowd. It has been claimed that a dense crowd, such as occurs on a boat landing or bridge approach, will not in ordinary cases weigh more than 20 lb. per sq.ft. The new experiments, reported by Hunscheidt in *Zentralblatt der Bauverwaltung*, Mar. 4, 1916, show that moving bodies of people may produce considerably greater loads.

A group of 250 men in two lines similar to company formation, but with the ranks moved forward into close

contact, was equivalent to a load of 85 lb. per sq.ft. A mixed group of 400 men, women and children, arranged in four ranks moved up into close contact, gave exactly the same unit load. Grouped in a similar rectangular formation, but without arrangement into rows, they occupied a slightly smaller area, loaded to 98 lb. per sq.ft.

When this group was set in motion, walking forward in the direction of the length of the rectangle at the rate of a slow-moving crowd (about 1½ mi. per hr.), the load was found to be 40 lb. per sq.ft. A group of 40 soldiers in column of fours, 10 ranks (moved up to a clear spacing of 20 in. between ranks), proceeding in normal march step, covered an area 8x26 ft. and represented a unit load of 29½ lb. per sq.ft.

Setting a Heavy Elevated-Railway Girder

Some heavy pieces of steel were handled in constructing the Jerome Ave. elevated-railroad structure, Bronx borough, New York City. S. A. Callahan, foreman steel erector of the Million Bros. Co., New York City, describes the handling of a heavy cross-girder recently set at Kingsbridge Road and Jerome Ave.

This cross-girder weighs 44 tons, is 75 ft. long and 9 ft. 4 in. high. South of the girder is a 100-ft. span consisting of four 12-ton platform stringers and six 20-ton track stringers. A 65-ft. span frames into the north side of the girder, carrying the mezzanine floor and ticket platform of the station at that location.

The equipment at hand consisted of a wooden stiff-leg derrick traveler having a 78-ft. steel boom, capable of lifting a load of 25 tons with the boom at an angle of 45° with the mast, and a 12x12-in. gin pole, 32 ft. high. The latter was set 24 ft. in from the east end of the span (toward the center line of the structure) and was guyed by ¾-in. steel cables to three columns previously erected and to two telegraph poles near-by.

The gin pole was rigged with a set of falls having two four-sheave blocks, one being fastened by a shackle at the top to the steel collar and the other fastening to the girder by means of dogs or hooks (Fig. 3). These were reeved with ¾-in. line, led through a snatch block

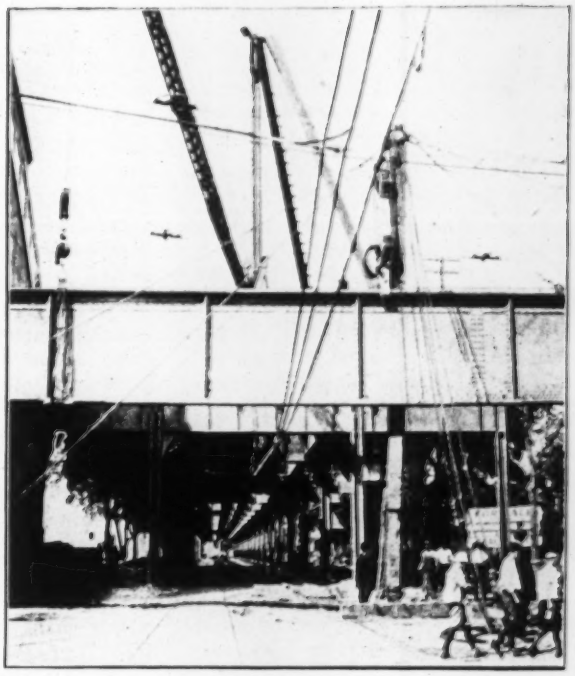
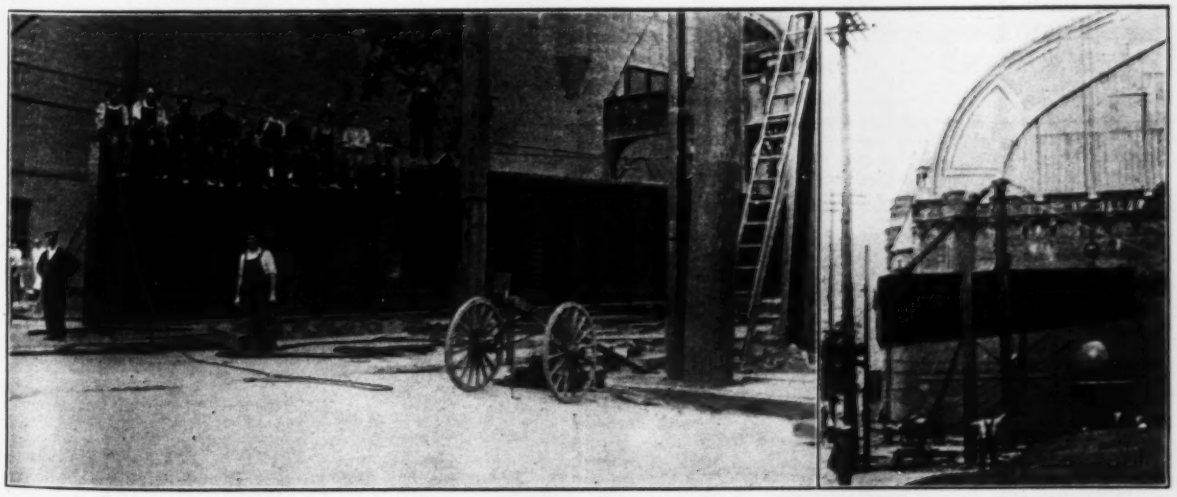


FIG. 3. GIRDER SET IN PLACE; TACKLE NOT YET REMOVED

(lashed 12 in. from the bottom of the pole) to the lower drum of a double-drum engine set on the ground. The engine was lashed with ¾-in. cables to a telegraph pole and to one of the elevated columns.

When the pole was fully rigged, the dogs of the derrick were lowered and hooked to the west end of the girder (lying on the east side of street) and the girder dragged on six 3-in. steel rollers to the position for raising. The dogs of the gin pole were then hooked 24 ft. from the east end and those of the derrick 14 ft. from the west end, and the girder was hoisted without difficulty. The gin pole carried approximately 27 tons and the derrick 17 tons.

The working force consisted of a foreman, eight bridgemen and four helpers. Street car and vehicle traffic on Jerome Ave. was tied up for 3 hr. and 45 min.



FIGS. 1 AND 2. GIRDER IN PLACE FOR RAISING; BEING LIFTED. WEIGHT, 44 TONS; LENGTH, 75 FT.; HEIGHT, 9 FT. 4 IN.

Enlarging a Flood Channel by Unusual Methods

It may be recalled that Austin, Tex., was among the Southwest cities which suffered most in actual loss of life by the floods of 1915. The city is much cut up by gullies and watercourses, which normally carry very little water. Such a one is Waller Creek, which passes through some of the poorer parts of the city and in which a score or more people were drowned by the sudden rise of water in one of the later floods of 1915.

Fig. 1 shows the crossings of Waller Creek under Red River St. and East 11th St. The bridge on Red River St. (Fig. 2) is a recent structure of reinforced concrete and withstood the floods without injury, but the old stone arch bridge on East 11th St. (Fig. 3) was considerably damaged, although not beyond repair.

To have enlarged the existing waterway of the two bridges would have meant rebuilding them, and the widening of the channel between would have required the condemnation of the corner property (Fig. 4), on which the owner placed a high valuation. Under these conditions it was more economical, all things considered, to provide additional waterway by an entirely new channel around the corner property. This new culvert is located entirely in the highway, as Fig. 1 shows. Fig. 5 illustrates the construction work on this culvert.

The new waterway was divided on the center line into two 13½x9-ft. box culverts, so as to give short spans to the concrete slab floor. The side walls, 18 in. thick at bottom and 12 in. at top, are reinforced with enough

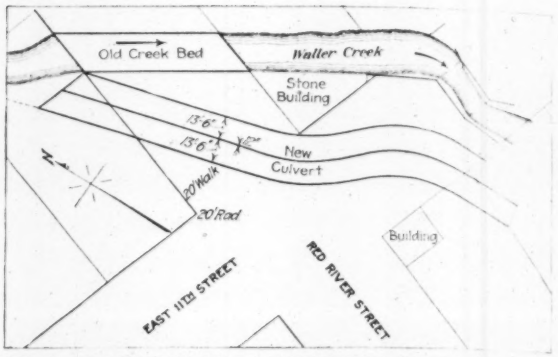


FIG. 1. PLAN OF NEW CULVERT FOR WALLER CREEK, AUSTIN, TEX.

vertical rods to tie the 12-in. cover reinforced slabs to them. The upstream end of the culvert extends over into private property (see Fig. 1), the lot being vacant at present. Instead of purchasing the required corner of the lot, the city acquired an easement by agreeing to roof it over in a manner strong enough to support any structure that may be erected there.

The upstream intake of the new channel requires the removal of the west wing wall of the Red River St. bridge and the construction of a head wall for the new culvert at right angles to it. The destruction of this wing wall was the most formidable part of the work and at the time the views were taken had not progressed very far. The attempt was then being made to break it up with sledges and drills, but the concrete was very solid.

FIG. 2. RED RIVER ST. BRIDGE OVER WALLER CREEK, AUSTIN, TEX.

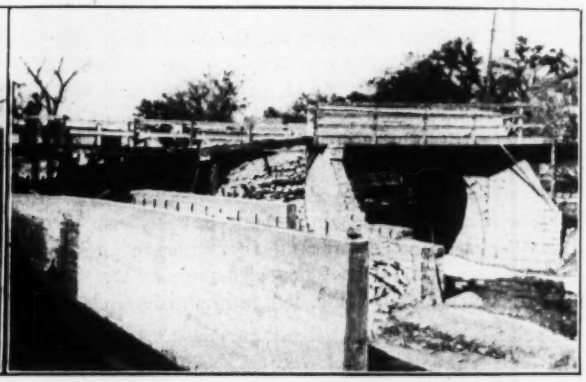


FIG. 3. ELEVENTH ST. BRIDGE OVER WALLER CREEK, AUSTIN, TEX.

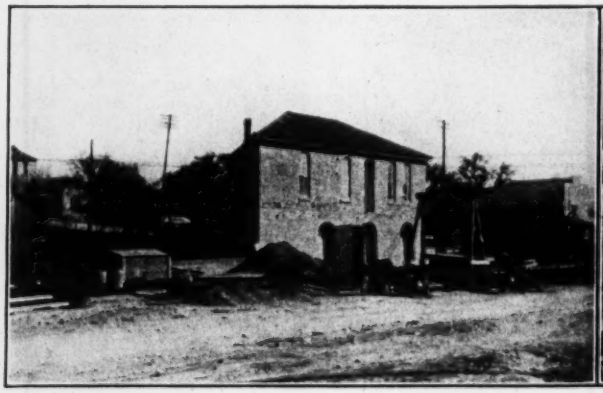


FIG. 4. CORNER HOUSE DIVIDING OLD AND NEW CHANNELS OF THE CREEK

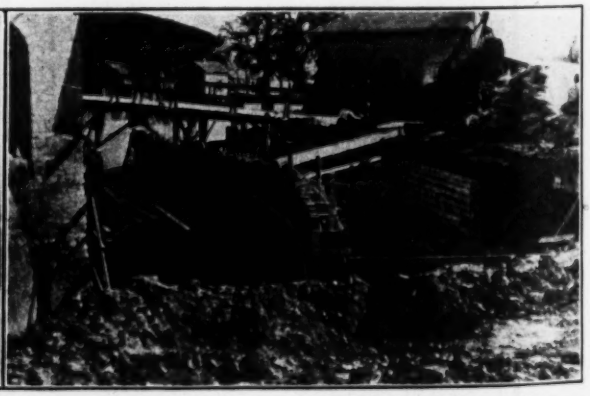


FIG. 5. CONSTRUCTION OF NEW CULVERT FOR WALLER CREEK, AUSTIN, TEX.

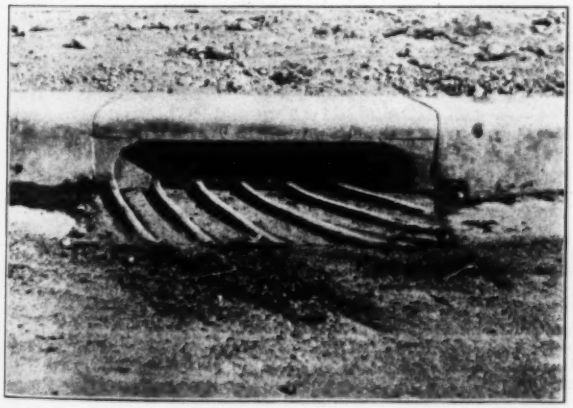
One criticism of the old concrete bridge, shown in Fig. 2, is that the structure does not provide a waterway commensurate with its span length (23 ft.). The floor over this span is carried on concrete girders extending about 15 in. below the floor slab, so that not only was headroom reduced, but the flow of the water much obstructed when the creek was carrying enough water to fill the culvert, as happened several times in 1915. Hence, it is seen that the new double channel with a plain slab floor provides more waterway than a single channel with a longer span.

The city engineer of Austin is M. C. Welborn. It should be added in fairness that none of the existing structures illustrated were designed or built by him.

NOTES

Load from Walls on Lintel Beams—Textbooks state that when an imperforate wall is built upon a beam the load on that beam may, owing to the bond of the brickwork, be assumed as the weight of the brickwork inclosed by an equilateral triangle that has the clear span for its base. It is dangerous to make this assumption, for it cannot hold good unless the bond is practically perfect and all the vertical joints filled solid with cement. Unless you watch every brick, the work is not done in this manner. And if by the bond all the load of brickwork above the equilateral triangle can be transferred direct to the supports, why should not any portion of the load near the support or any concentrated load actually over the support be distributed over and toward the center of the span? The method of building a wall brick by brick with soft mortar insures that the whole of the masonry over the span is borne by the beam, and this view is borne out by a recent case. At some time a comparatively small opening was made in the wall in the ground story no lintel or arch inserted to carry the brickwork over. A crack started from the center of this opening and, after extending upward for a few feet, became bifurcated, the double crack some 3 in. in width extending to the top of the building.—W. G. Perkins, District Surveyor for Holborn, before the Concrete Institute, London.

Curb Inlet Casting—The accompanying illustration shows a curb catchbasin inlet with a casting of peculiar construction. This was designed in the office of the city engineer of Austin, Tex., and is being extensively used in that city, particularly on steep grades. It has been found that any bar or screen over

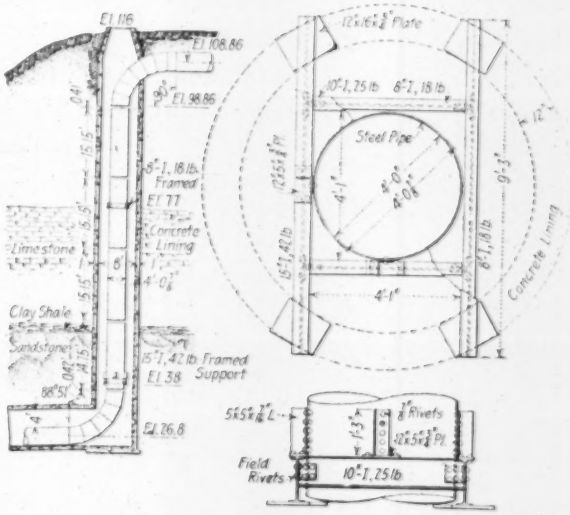


CURB INLET, AUSTIN, TEX.

the opening, either in the curb or in the gutter, clogs up so badly that a good share of water runs past, especially on steep grades. The special casting shown serves the double purpose of covering the inlet chamber and of deflecting the running water into the curb opening. It is made of iron about ¾ in. thick and has six ribs approximately on parabolic curves, extending about 1½ in. above the plate of the casting.

Hoisting-Engine Signals for derricks and elevators used in building construction are given frequently by wires leading from a gong at the engine to the floor on which the derrick or headframe is located. If these wires are exposed, they are liable to be struck by planks or workmen, giving false signals that may lead to accident. The Illinois Department of Factory Inspectors, whose work covers building construction and repair, requires all such signal cords or wires to be inclosed in pipes.

Steel Support for Vertical Steel Water Pipe—The accompanying drawings show the steel framework used to support the vertical portions of a 48-in. riveted steel water-supply main now being laid beneath the Mississippi River at Minneapolis, Minn. On each side of the river a shaft is to be sunk in the sandstone and lined with 12 in. of concrete. The



STEEL SUPPORT FOR VERTICAL RUNS OF 48-IN. STEEL WATER MAIN, MISSISSIPPI RIVER CROSSING

main will be placed in these shafts and will be carried beneath the river in a trench, as stated in "Engineering News" of Feb. 10, 1916, p. 291. J. A. Jensen is supervisor of waterworks, and F. W. Cappelen is city engineer.

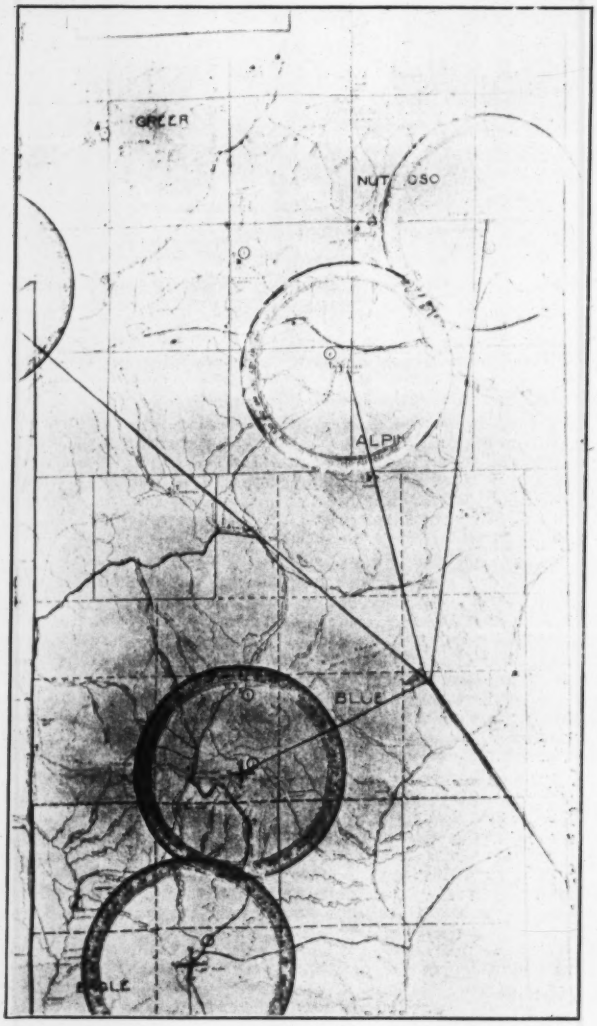
A Sawmill Refuse Burner Was Moved by Scow at Everett, Wash., on Mar. 31. The burner is a brick shaft 13 ft. in diameter by 30 ft. high and is said to weigh about 78 tons. It was moved from the Mann shingle mill a quarter mile along the sound. W. L. Imus carried out the work. The chimney was blocked and jacked up and rolled onto the deck of the scow by a windlass, without accident.

The Production of Sand-Lime Brick is on the increase, according to a recent report of the United States Geological Survey. The 1915 sales are reported to have been 179,643,000 brick, valued at $1,135,104, which was an increase of 7,014,000 brick, or 4% in quantity, and of $76,592, or 7% in value, over 1914. Michigan was the leading state, reporting sand-lime brick marketed to the value of $286,948, or over one-fourth of the quantity and value of the sand-lime brick sold in the United States. Minnesota was second and New York third. Many operators are reported as enlarging the capacity of their plants in anticipation of increased business during 1916.

Pitometer Survey for Leaks and Pump Slip—On May 25, 1915, the Board accepted a proposal of the Pitometer Co., New York City, for a pitometer survey of the distribution system of the city and a test for slip of the pumps. The survey was contracted for the sum of $3,000, with a guarantee to save sufficient water to pay for this amount, based on a cost of 3c. per 1,000 gallons, extending over a period of one year; and it also included a check of the register of the large meters in the system. This contract indicated that not less than 274,000 gal. of leakage daily would be found and stopped. A comparison of our pumping data from Mar. 7 to July 11 (the date when the first large leaks were stopped) showed an average Sunday pumping record of 6,228,000 gal., while on Sunday, Sept. 25, it amounted to only 5,410,000 gal., a saving at that time of over 800,000 gal. daily, or three times the amount of the guarantee. Another method of testing the saving was a comparison of pumpage during the night shift from 12 midnight to 8 a.m., Sunday. The average pumpage on this shift from Mar. 7 to July 11 was 1,857,000 gal.; and on Sept. 25 this pumpage amounted to only 1,452,000 gal., a reduction for 8 hr. of 405,000 gal. This amount for the entire 24 hr. would represent a saving of 1,200,000 gal. Subsequent records taken during the year 1915 show this computation to be well authenticated.

The total expense of this survey, including installation of the 31 corporation-cock gaging points with permanent cast-iron street boxes and such other connections as were necessary for testing meters, pumps and transmission lines, etc., together with the house-to-house inspections and examinations and repairs to leaks, etc., amounted to $4,371. The slippage on the 10,000,000-gal. R. D. Wood pump (in service since 1902) was shown to be 4.22%; for the Holly-Gaskell, equipped with Hill valves, the slippage was shown to be 5.56%, and the 10,000,000-gal. Snow pump at the Upper Station, installed in 1895, showed an average slip of 5.76%. The transmission main between the two stations, 8,725 ft. in length, showed a discrepancy of only 1.13%; but as this was negative, it proves there was no leakage in this line.—From 1915 report of Water Board, Auburn, N. Y., J. Walter Ackerman, engineer and superintendent.

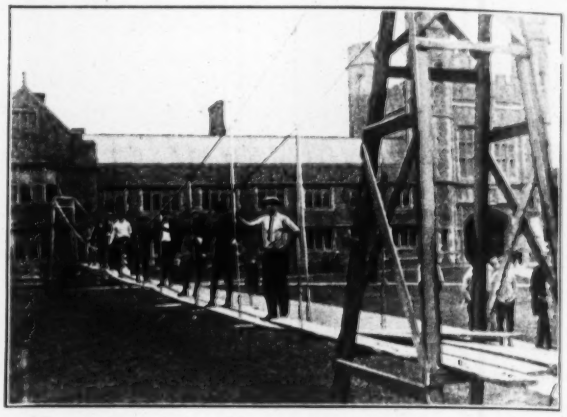
Locating Fires in National Forests is quickly accomplished at any of the Forest Service offices by means of maps, accurately plotted to scale, with a properly oriented circle centered on each of the lookout stations. The zeros of the circles are on the meridian, and the circles are graduated to degrees. As soon as a fire is discovered, the observers at each lookout station take the azimuth or bearing of the fire and at once telephone the reading to the Forest Service office. As soon



OFFICE FIRE MAP OF THE U. S. FOREST SERVICE

as readings from two lookout stations are received, the location of the fire is determined graphically by means of intersecting silk threads. These threads pass through the centers of the circles (the lookout stations) and are counterweighted on the back side of the map, so that when not in use only a small ring is in sight. As soon as the location of the fire is thus determined, the fire-fighting crew is assembled and dispatched from the headquarters office.

Students Built a Suspension Bridge in 45 Min. on Nov. 1 at Washington University, St. Louis, during the annual "Class Jones Pageant." The bridge was 120 ft. between supports, consisted of 15 panels at 8 ft., was designed with a minimum factor of 2 to carry 100 lb. dead-load and 200 lb. live-load per panel and was erected on the campus by nine senior students in civil engineering. The general appearance is shown by the accompanying view. The cables consisted of two 3-in. wire ropes, running over 16-ft. horses or bents (made up of 4x7-in. An 8-in. I-beam across an opening in a masonry wall did service as the west anchor. The east one consisted of a 3x10-in. oak timber across a basement window opening, the



ST. LOUIS STUDENTS' SUSPENSION BRIDGE

thrust being taken partly by the wall of the building and partly by struts to the retaining wall of the window well. The construction operations were simple. The cable was first anchored at the west end by sliding the I-beam through a loop at the end of the cable. Two men on each bent then hauled up the cable simultaneously, and the slack was immediately taken up by a block and tackle at the east end, as soon as the cables were in place on top of the bents. The connection was completed at the east end by passing the loop of the cable through a wire-rope sling and inserting a pipe through it. The end floor-beams, consisting of 2x6's 4 ft. long with a loop of rope at each end, were hooked up to ¾-in. rope hangers, which were already in place on the cable, by means of 40d. spikes bent into S-shape and fastened at the ends of the hangers. The deck consisting of two 2x10-in. boards in 8-ft. lengths, was then placed in position. The first two hangers at each end were long enough to be reached with a stick and pulled over to the preceding panel point. From here on out to the center a swing was used consisting of a 2-in. pipe riding across the two cables and carrying a 2x4 about 3 ft. long by two heavy wire hangers. Working from both ends in this manner, the bridge was completed without falsework or any help from below.—W. C. Bernard.

Levee Construction on the Illinois River—It is common practice to build the levees along the Illinois River by dipper dredges, the dredge riding in a wet borrow pit from which the material is cast upon the bank. This method makes a rather rough and irregular levee. The borrow pit is frequently about 60 ft. wide, with a 10-ft. berm between the borrow pit and the toe of the levee. The usual top width is theoretically about 6 to 8 ft., and the side slopes 4½ on 1 or 5 on 1. It is the practice to leave a space of about 200 ft. between the borrow pit and the low-water river bank. The trees and brush upon this space are left in place to serve as a "wave break" for the protection of the levee. The construction by dredge is undoubtedly the best method to employ for high levees, but leaves them with a very irregular top; and in one instance the inequalities in the elevation of the levee top gave the district 2 ft. less protection than the plans intended or the average material handled made possible. As a rule, the levees are allowed to be covered with a rank growth of weeds. On one of the private districts the owner proposes to fence his levees and to pasture them. This would keep the surfaces exposed to view, so that damage from burrowing animals or from other causes would be readily noticed, and the presence of cattle would tend to drive away pests. When the danger from poorly kept and poorly inspected levees is considered, this plan seems worthy of consideration by landowners.—Report on "The Illinois River and its Bottom Lands" made to the Illinois Rivers and Lakes Commission by John W. Alvord and C. B. Burdick, consulting engineers, Chicago.

Editorials

Incombustible Construction

Development work in fireproof construction has hitherto been centered mainly on first-class construction—the needs of warehouse and office buildings and all structures serving public uses. Nothing less than full protection will do for buildings of this type. Every part of the structure must be capable of resisting the high temperatures of a conflagration lasting through a period of several hours at least. In addition, mechanical strength is important.

Low-grade "fireproofing," if it existed, would have fully as great a field as the present high-grade work. But there are few forms of building material in the market today that can be classed in this group, and as a whole the field is untouched.

The possibilities in dwelling-house construction alone are vast. A few experimental houses have been built in the endeavor to develop suitable forms, with but little success so far. When satisfactory materials and methods are developed and made regularly available, they are bound to revolutionize our building practice.

Incombustibility, ease of applying and handling, and cheapness are the three first essentials in the materials required for such service. As to fire resistance, this may be relatively low, both with respect to maximum temperatures and with respect to maximum time of exposure. It can be assumed that a material meeting the other requirements will possess sufficient fire resistance for all the needs of the case.

Cheapness is vital, however. The material itself must be low-priced, and the cost of placing and applying it must be moderate.

The popular notion is that the use of hydraulic cement or concrete is the logical solution of the problem. In so far as this means mass application—or continuous construction as distinguished from block construction—there is room for doubting whether the notion is right. Certain it is that no cheap enough method of mass application has been discovered yet; or perhaps it would be truer to say that the existing methods have not yet been brought down to a cost figure that is low enough for the purpose. As to pouring, even the large-scale attempt of Edison failed to achieve success. As to spray application on a framework, it can be said that the framework element is not so difficult to dispose of, but that the cost of the spray work is prohibitive.

The possibilities of the spray method have not been exhausted, however, and further progress may be hoped for. The same can be said of block construction—a method in which the greatest relative progress has been made hitherto, by virtue of successively repeated competitive efforts at bringing down the cost and increasing the ease of application.

A point worth remembering is that both the methods just mentioned permit securing not only a low grade of fireproof construction, but also various intermediate grades, up to full standard protection. This is interesting and important for the future. For the present the situation is that efforts at development should center on low-grade construction, as this is the field in which lies the large market.

Is Character the Fundamental Requisite for Engineers?

Dean Marston, of Iowa State College, has applied a practical test to that method of rating an engineer's ability which was developed from correspondence between Prof. C. A. Mann, of the Carnegie Foundation, and a number of engineers and reported to the American Society of Civil Engineers last January (*Engineering News*, Jan. 27, 1916). Professor Marston has taken six of his acquaintances with whose personal characteristics he is familiar, and without prejudice he has assigned to each his proper rating on the so-called "score-card." The tabulation so derived is printed on another page of this issue. As was to be expected, the banker, the grocer and the merchant rate higher as engineers than do the three men who are successful practitioners of engineering.

We say "as was to be expected" advisedly, for thoughtful criticisms of what for lack of a more explicit term may be called the "Mann score-card" have all pointed out the absurdity of assigning only 13% of an engineer's ability to technical qualities. The essential error in such an estimate is succinctly shown in Dean Marston's paper and need not be amplified here, except to repeat that the qualities involved are largely those necessary to every human being and not alone to the engineer. What can be emphasized is that the average engineer—particularly the older engineer whose practice is largely behind him—is more than apt at first to applaud the implications of the test-card and to maintain that character is of vastly more importance than technique in a successful engineering life. Indeed, as near as one can judge the unexpressed feelings of a crowd of 700 men, this was the general attitude with which the American Society of Civil Engineers received the first announcement of the classification last January. That such a feeling can be only superficial and must be reversed by careful consideration seems to be obvious.

It is perhaps unfortunate that this score-card has had so much publicity without due consideration of what it is. The list of qualities and their assigned weights are careful collations of the replies of 1,500 engineers to the query, "What do you consider the fundamental characteristic necessary to success in engineering?" In an effort to ascertain whether such a classification really represents the ideas of the profession Professor Mann has sent out the ungraded list, with the request that the subjects be graded according to the individual's ideas of their value by "numbering the six groups in the order of importance which you give them in judging the reasons for engineering success and in sizing up young men for employment or for promotion." This should bring a quite different

result. That 1,300 out of 1,500 engineers—that is, 87%—consider some one of the elements that go to make up character the fundamental necessity for engineering success does not mean that the average of these 1,500 engineers would rate the elements of character as making up 87% of the necessary qualifications of an engineer.

Pork in the River and Harbor Appropriation Bill

The River and Harbor appropriation bill is pursuing its course through the House of Representatives. The House is going over it item by item in Committee of the Whole in the old-fashioned way, with the notable exception that an active minority, headed by Congressman Frear, of Wisconsin, takes every opportunity to criticize the items in the bill which call for the expenditure of Government funds on rivers where the official reports demonstrate no traffic exists to justify the outlay. We quote from the debate of Apr. 6 on the following item in the bill:

Santee, Wateree and Conagree Rivers, S. C.: For maintenance of improvement, $55,000.

Mr. Treadway—I move to strike out this paragraph. In reference to the Wateree River we find that the work on the river has been snagging only. No dredging has been done. We have spent on that project up to June 30, 1914, $186,307.

The report says that it is not practicable to state the percentage of the completion of the project. The work is snagging and will be continued indefinitely. The depths remain about the same as before the improvement—namely, 3 to 4 ft. As to the effect of the improvement, they say that the project has had no effect on freight rates, and there was practically no business on the river during the year. Some cordwood and staves were cut along the river and rafted out to market.

It would be a great deal better for the Government to buy the staves and logs and let them stand as timber rather than to get the snags out so that the staves and cordwood can be got down to market.

Mr. Mann—Mr Chairman, I suppose there is water in the Wateree River, judging by its name. Here is a river where up to date we have expended $195,000, of which $135,000 was for maintenance; and it is contemplated to use $15,000 the next year for maintenance. It is not expected that commerce on the river will grow any. It is only for the protection of existing commerce.

What is this commerce? I read from the report of the committee:

Commercial statistics. None reported for the year. A few logs were floated and some shingles and staves were hauled by a gasoline boat.

That is the commerce of the river—a gasoline boat—and owing to the high price of gasoline I am confidentially informed that that boat has gone out of business. But to take care of existing commerce it is proposed to expend $15,000 in order that these few logs may be floated down the river (if there is any water in it they would float anyway) and to provide that a gasoline launch may take down a few more shingles and staves. The gentleman from Massachusetts [Mr. Treadway] said that the Government might buy these shingles and staves and let them stand as timber. Mr. Chairman, the Government could afford to buy the shingles and staves and save half the money. We could build a house there, put the shingles on the house, make the staves into barrels and fill up the house and let them lie there and rot and be ahead $7,500 on the appropriation.

The foregoing quotation is not exceptional, but typical of the criticism to which a large proportion of the projects contained in the pending bill are being subjected. While the majority back of the bill is sufficient to secure the adoption of the projects substantially as reported by the majority of the House Committee, it is no small gain to have the facts concerning this foolish waste of public funds openly presented on the floor of the House. Another example of the keen debate is the following paragraph relating to the water-hyacinth removal:

Removing the water hyacinth, Alabama, Mississippi, Louisiana and Texas: For the removal of the water hyacinth from the navigable waters in the states named, in so far as it is or may become an obstruction to navigation, $20,000.

Mr. Miller of Pennsylvania—Mr. Chairman, I strike out the word "hyacinth." If the statements the gentleman from Wisconsin [Mr. Frear] are true absolutely throwing away $20,000,000 on improv rivers worthless to commerce, where there is no where there is not much water and in this case, where have to take the weeds out in order that boats may the streams.

We ought to remember, gentlemen, that a good gen who used to be over in the Senate from Ohio, Mr. Burton who stopped the waste of public funds, is not there now. In the last Congress he saved this country $42,000,000 b opposition. There will be no person over in the Senate year to do that; and when this bill goes from this House with its $39,000,000 or $40,000,000 it will come back with $8,000,000 or $10,000,000 more, and we will pass it, not to benefit the rivers, but to benefit the people that want it.

Mr. Harrison—Does the gentleman propose by his amendment to strike out the word "hyacinth"?

Mr. Miller of Pennsylvania—Yes.

Mr. Harrison—If that word should be stricken out, we would be appropriating $20,000 to remove the water.

Mr. Miller of Pennsylvania—If we remove the water, the hyacinths will not grow. [Laughter.]

Mr. Mann—It would not take that much money to remove the water from most of these rivers.

Power Under Difficulties

The completion of a hydro-electric plant on the canals of the Salt River reclamation project in Arizona permits an unusual study in the weighing of remarkable construction and operating difficulties against the great benefits of an ample supply of moderate-priced power in that arid country. A fall of 117 ft. and a flow of up to 720 sec.-ft. right at the load center of an existing transmission and distribution system were the alluring bait; the great variation of flow, the large burdens of silt and pebbles, the presence of a precipitating chemical content and a 90° temperature variation were among the peculiar barriers to easy design and smooth operation. The results secured, both in interesting features of design and efficient performance, as noted elsewhere in this issue, must be regarded as a notable technical achievement—the credit going no less to the contractors on hydraulic equipment for their development of apparatus than to the Reclamation Service designers for their work on the scheme as a whole.

Probably no power development in the country has as little iron and as much concrete exposed to the water flow as has Cross Cut station; with the exception of the trash racks, butterfly headgates, turbine nozzles, buckets and discharge baffle, there is no exposed metal. This suppression of steel is followed throughout the plant. One feature, as yet unexplained, is the very high friction-head coefficient for the penstock—running as high as for a brick sewer or an old cast-iron line. The lack of available figures on the properties of a sufficient number of reinforced-concrete penstocks prevents easy comparison with this case at the present moment.

Interesting as such matters are, however, chief interest centers in the low-head vertical-shaft impulse wheel, both for the features of design and the excellent performance under a head which heretofore has been regarded as far below that economically utilizable by the tangential wheel—the units are of 1,000-hp. capacity, are under only 107 ft. net head and develop an efficiency of 83% well sustained over a wide load range. The scheme of testing the Cross Cut turbines also is worthy of comment for its ingenuity—and perhaps for its chance of trouble in the hands of less skilled operators. However, if the builders know in advance that the buckets are to be subjected to reversed loading and the Kingsbury bear-

ing is to be run backward, there seems to be no reason why the dangers cannot be readily prevented and the plan extended to testing other impulse-wheels.

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Bug Run or New York City

There are 115 possible landing places for a hostile army on the Atlantic Coast between Boston and New York, for which no adequate military maps are available; the only military map of the district surrounding Charleston, S. C., is that made by the Confederates in the Civil War; there is no map of the environs of New York City on which is to be found the information necessary for military operations of defense. These are only a few of the facts that make it apparent that military mapping—a practice quite distinct in method and results from civil mapping—should be prosecuted with the utmost dispatch. The Chief of Engineers in a recent appearance before a Congressional committee said that this military mapping was progressing very slowly because the Corps of Engineers, that branch of the army qualified to conduct such work, was otherwise so extensively engaged as not to permit it to devote much time or effort to the necessary mapping operations.

The 1915 report of the Chief of Engineers tabulates the detail assignments of the 207 officers in the corps. Of these, 112, or 54%, are engaged in exclusively military work, which includes service in the Washington office, with engineer troops, on fortifications and at military schools. On exclusively nonmilitary work there were 56 officers, or 27%, detailed to river and harbor work, at Panama, in the city government of Washington and in the national parks. The remaining 39, or 19%, were partly in military work, though the major part of their time was devoted to essentially civilian pursuits.

It is not the purpose of *Engineering News* again to bring up the generation-old discussion as to the desirability of taking the river and harbor work away from the army. The arguments on both sides are time-worn and, unfortunately, have had little enough to do with the persistent refusal of Congress to consider the change. But this journal does submit to the advocates of preparedness—particularly those in the army itself—that the deductions from the foregoing facts are obvious.

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Railway Engineer's Experience as City Manager of Tucson

Tucson, Ariz., has ostensibly a city manager, but unfortunately, as in Abilene, Kan., the city manager's office is not established by charter. An attempt has been made to graft the city manager on the old city charter, which provides for a mayor, six councilmen, city clerk, treasurer, tax collector and city marshal—all elected by popular vote.

When the success of neighboring cities under the city-manager plan gave rise to popular agitation for the adoption of this form of government at Tucson, the local politicians appear to have forestalled popular action by agreeing to the appointment of a city manager, which could be done under the present charter. The charter permits the mayor to appoint, with the confirmation of the City Council, any officer necessary to help carry out the work of the city. Accordingly, the mayor sought and obtained the services of C. K. Clarke, a former division engineer of the Southern Pacific Co. Nominally, the management of the city, with the exception of the police department and its elective head, was placed in Mr. Clarke's hands.

Tucson is a rapidly growing community of about 20,000 population, and there is much public improvement work under construction. In connection with these public works and because he has organized and supervises a central purchasing bureau and all city accounting, the engineer city manager has been able to accomplish a great deal for the public good. But he is fettered by petty politics and has, as can readily be appreciated, only such real authority as the mayor and council in the goodness of their hearts may see fit to extend. In plain words he is a city manager in name rather than in reality. His appointment was merely a clever ruse of the politicians to forestall a city-manager charter.

The moral of his experience is not far to seek. An engineer of many years' experience in doing things and in the exercise of responsibility and authority will find a thorny path if he must be governed and limited by politics and politicians in his new capacity as city manager. His powers must always originate with the electorate of the city, and his responsibility must be primarily to the people. Engineers should be on their guard as citizens to prevent being hoodwinked into any pseudo form of city-manager government; and they should be cautious in accepting positions that are almost certain to bring more grief than glory, or even appreciation, unless they are willing to sacrifice their peace of mind for sheer love of service.

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One brief extract from the proceedings of a recent structural patent suit has all the force of many pages of argument against the absurdities of our patent procedure. The issue was the alleged infringement of a well-known reinforced-concrete bridge patent, and the decision rested as much on the arrangement of the reinforcement and the general functions of reinforced concrete as it did on the legal status of the patent. Toward the end of the second day of the trial, as recorded on page 152 of the 174 pages of testimony, the attorney for the defense had occasion to use the phrase, "assists the concrete in resisting thrusts and bending moments." "What," said the learned judge, with commendable though belated curiosity, "what is a bending moment?"

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Wholesale contract-letting is being tried by one state highway department as a deliberate plan to get the best bids. In part the purpose is to enable the various intending bidders to select the jobs and locations best suited to their facilities. An advantage is also expected to result from the coming together of contractors and material men at the big letting. In both matters all parties to the work should benefit. Unnecessary bids will be eliminated or reduced by concentrating the attention of the bidders on the kinds or locations of work that they can handle most efficiently, thereby keeping them from wasting time and expense in bidding on other jobs. This policy should at the same time help to prevent the occasional unduly low bid, the result of chance and ignorance combined, which if accepted is likely to prove disappointing to both sides of the contract. The plan is interesting in various ways; and if its trial proves successful, it will furnish a useful precedent.

Letters to the Editor

Some Reasons Why Tar Carpets Have Peeled Off Concrete

Sir—In the article and editorial appearing in your issue of Feb. 24, on bituminous carpets on concrete roads, reference is made to the company organized to exploit the system. I was employed by that company as an engineer and representative, and in the latter part of 1912 I made an inspection of all the concrete roads that were built or under construction in an Eastern state, where it was proposed to use a bituminous carpet.

I was surprised to find the utter lack of care in the construction of these concrete roads. The concrete in practically all cases was made from bank-run gravel, and this in most cases was taken from creek bottoms and pits containing clayey gravel. No effort was made to test the material. Nearly all the gravel I saw was full of clay and sediment and contained very little sand.

The resulting concrete was the poorest imaginable. The surface was little harder than baked clay. On one road I cut out pieces half an inch deep in one place after another. On another road I saw where an ordinary wagon had passed over the road about a week after the concrete had been laid and made a rut 2 in. deep in it. The engineers and inspectors on the roads knew nothing about concrete, and the officials over them knew less. Furthermore, they would not back up their engineers, so the contractors did as they pleased.

You can imagine my disgust at the situation, for just previous to this time I had been for five years in charge of work on the New York Barge Canal, where I had laid thousands of yards of concrete. I wrote the company and explained conditions to them, stating that, if it wanted to do any business, it would have to get proper concrete to do it on; but the company was for selling the bituminous material, regardless of where it went. The company itself laid a demonstration piece in Central Park, New York City. When I inspected it a short time afterward, I found the company had not done much better work than the contractors referred to.

I cite these facts to show why concrete roads, as well as the bituminous surfacing thereon, received a black eye in the East when they were first promoted.

Under these conditions I resigned my position and went with a company on the erection of a tar refinery in Birmingham, Ala. While I was there, the City of Birmingham wished to try some bituminous treatment on concrete. On all the main streets in Birmingham, between the car tracks and for 2 ft. on each side, the streets are paved with concrete of an exceptionally good quality, made with a clean sharp sand. The remainder of the street is a pavement of different type. We brushed the concrete clean and applied the tar and a cover of clean coarse sand. As far as I am aware, it has never peeled off.

After finishing my work with this company, I went with the New York State Highway Department after it was reorganized and took charge of some roads in northern New York. One was between Lake George and Warrensburg, the gateway to the Adirondack Mountains. This was a concrete road with a bituminous top. The road was partly built when I arrived on the scene. The completed portion had been built of a fairly good sand and gneiss, but was not in very good condition, having been laid too dry and some of it having been frozen. I patched up this section and finished the remainder the best I could under the specifications, which did not call for any refinement in such things as finish, grade, side forms, etc., and allowed the use of continuous mixers. After the concrete was completed, we opened the road to traffic for two months before putting on the bituminous top. It was in the middle of the touring season, and the road received a very heavy traffic, which removed all the laitance. Afterward we swept the concrete thoroughly and applied hot tar in two coats on one end and one coat on the other end. In the middle of the road for about 1,500 ft. we treated a section with hot oil. A cover of crushed stone was put in place and rolled, then after it had bled, covered with clean sand. The cover on this road never peeled. It stayed in place two years, until it wore out, when it was renewed. My conclusions are that, in order to have a bituminous carpet stick to a concrete base:

1. The concrete must have a hard durable surface, nothing leaner than 1 : 2½ : 5, and must be mixed with a clean sharp sand.

2. It must be open to traffic until the crust of the concrete has worn off and the pores are exposed.

3. The surface of the concrete must be absolutely clean when the top is applied.

In cleaning the road it must be swept with a wire broom or other stiff broom, to remove all foreign material; then it should be sprinkled and swept with a house broom, until in drawing the palm of the hand over the surface of the concrete no white mark is left on the palm. The bituminous material should then be applied and broomed into the concrete, to remove the remaining dust, if put on by hand; or a heavy pressure should be used, if it is placed mechanically.

I have put a good many tops on concrete roads under this method and have never had them peel; but I would again emphasize that the concrete must be of the best quality and made with the best sand, and the road must be absolutely clean when the tar is applied. Where a road is located in a clayey country, the clay will often be brought on the road by vehicles and then bake fast; it will be next to impossible to get the road clean.

I find tars stick better to a concrete surface than asphalts. O. H. E.

New York City, Feb. 29, 1916.

Sir—I have read with great interest the article by Manley Osgood on "Tar-Coated Concrete Pavement in Ann Arbor, Mich.," and your editorial on the same subject.

I have been especially interested in the superficial coating of concrete with tar materials ever since the first

experiment tried in Massachusetts in 1907 and 1908. The original road in Massachusetts, treated by the Massachusetts Highway Commission at Spencer, Mass., has been maintained with tar coatings for a period long enough to show that the method will work out satisfactorily on roads where the traffic is predominantly automobile traffic.

Another road in Massachusetts, coated in 1907 by Charles W. Ross, then Superintendent of Streets, Newton, Mass., shows equally good results. A cream of neat cement was spread over the old macadam surface of the Newtown Boulevard and was, after going through the winter, coated with refined tar. This has not been renewed up to the present time and is still in excellent condition. This portion of the boulevard receives automobile traffic only.

I believe that the failures in coating concrete with refined tar may be assigned to a number of reasons. I believe that the greatest number of its failures are due to its use on concrete surfaces which disintegrate beneath the tar coating and thereby cause the coating to scale off. In all cases of this kind the pieces of tar coating which scale off carry with them a scale of concrete on the under side.

The Spencer work in Massachusetts was opened to traffic for about a year before the first coat of refined tar was applied, so that the scale or floats were worn off before the tar coating was put on. Mr. Fletcher, State Highway Engineer of California, has benefited by this experience and always allows a period of wear on the concrete before the surface coating is applied. There are a number of other precautions which must be rigidly fulfilled when a wearing surface is to be produced, and the coatings must be carefully put on to get them uniform.

1. The concrete must be clean and in good condition before the coatings are applied. 2. The refined tar must be of the proper quality and heated to the right point before application. 3. The concrete must be warm enough and dry enough to make the refined tar stick. This is especially true if the coating is applied after midsummer. If it is applied before midsummer, a certain amount of adhesion will take place even if it does not adhere on contact. 4. The refined-tar coating is best put on in two layers, using ¼ gal. on each layer, with hard stone chips over the first coating and stone dust or sharp sand over the second coating. 5. A priming coat of very thin tar is sometimes necessary with certain surface conditions of the concrete or on concrete which has been subjected to wear for a prolonged period. 6. A thin coating of ½ in. cannot be expected to stand up under horse-drawn vehicles. In this case a 1½-in. to 2-in. surfacing is required, using the concrete as a base.

PHILIP P. SHARPLES,
New York City, Mar. 11, 1916. The Barrett Co.

Resin in Yellow Pine for Decay Resistance

Sir—In *Engineering News* of Feb. 24, 1915, p. 368, an article by Dr. Herman von Schrenk, entitled "Yellow-Pine Timber Graded Without Guesswork," gives in detail the grading rules of the American Society for Testing Materials and states that, if architects and engineers make use of these rules, the uncertainty in specifying yellow pine for heavy construction will disappear.

FIG. 1. THREE SECTIONS OF SOUTHERN YELLOW PINE SUBJECTED TO ATTACK OF DRY ROT FOR 3 YR.

The description of the application of the rule deals almost exclusively with the strength of the timber. The failures of yellow pine within the past few years which have caused its reliability to be questioned have not resulted from the lack of initial strength, but from its increasing tendency to rot.

The only parts of the new specifications that are directly concerned with the durability of yellow pine are the darkness of the summer wood, which is generally characteristic of resinous material, and the percentage of heartwood, which is a guarantee of durability if it is resinous. But heartwood of yellow pine is not always resinous, and nonresinous pine frequently has summer wood, which is dark.

The appearance of the summer wood depends considerably on the moisture that the wood contains and the

method of cutting the sections. Moreover, "dark" is a comparative term at best, and if it is to be used as a basis for important specifications upon which disputes may arise it should be clearly defined by comparison with some easily duplicated standard; the method of cutting the sections and the moisture should also be specified. This would make a cumbersome specification, difficult to apply, subject to uncertainties; and if all that is to be finally gained is an approximate index of the resin contained in the wood, why not definitely state the minimum acceptable percentage of resin, with the added descriptive clause that such resinous material has dark summer wood? The darkness of the summer wood is probably sufficient for ordinary grading purposes, but an analysis for resin can be resorted to in case of dispute, thereby making it possible for the engineer to determine definitely for himself whether he has received the timber that he requires and that he has specified.

A similar criticism applies to the percentage of summer wood as an index of density. There is no reason

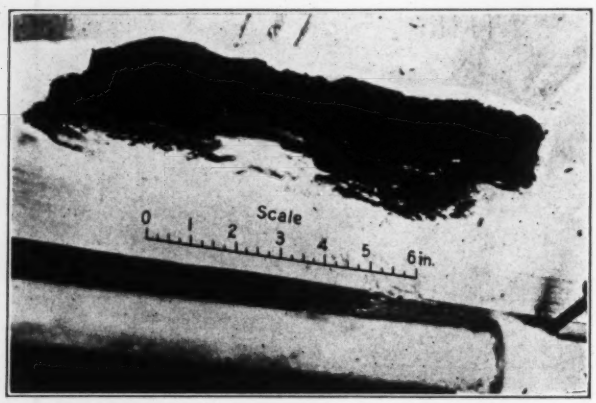


FIG. 2. PART OF FRUITING DRY ROT ON THE PLANKS SHOWN IN FIG. 1

why the actual acceptable minimum specific gravity for a given volume of wood should not be stated.

Fig. 1 shows three sections of Southern pine heartwood floor plank upon which a dry rot (*Merulius lachrymans*) plant has been growing for about three years. This plant has fruited regularly in September or October of each year, showing that the conditions of moisture and temperatures are favorable to normal growth and long life of this formidable destroyer of structural timber. Fig. 2 shows a part of the fruiting area as it appeared in October, 1914.

I think all the planks shown will pass the grading rules of the American Society for Testing Materials as "dense Southern yellow pine." The difference in their power and resistance to dry rot caused by the *lachrymans* plant is apparent.

The resinous section in the center of the picture is practically untouched, except superficially at the edges, where it has been in contact with the other two badly rotted specimens for three years. The three specimens were edge to edge in a floor, in the order shown in the photograph.

F. J. HOXIE,
Engineer and Special Inspector,
Associated Factory Mutual Fire Insurance Companies.
31 Milk St., Boston, Mar. 3, 1915.

[The foregoing letter was submitted to Dr. von Schrenk, who has replied as follows.—Editor.]

Sir—I have been much interested in Mr. Hoxie's comments on the recent specifications for Southern yellow pine, in which he argues that a minimum percentage of resin is essential to guarantee timbers against decay. I do not quite agree with Mr. Hoxie that the failures of yellow pine within the past few years have been caused by lack of decay-resistance rather than initial strength. As I have pointed out elsewhere, every single instance of failure to resist decay that I have examined has been due to high percentage of sapwood in the timbers.

Investigations are under way at the present time to determine with great accuracy exactly what function resin plays with regard to decay-resistance in various species of pine. We have at the present time, under the auspices of the Missouri Botanical Garden, a series of cultures, over 3,000 in number. These cultures consist of carefully selected pieces of long-leaf, short-leaf and loblolly pines having various degrees of density and various resin percentages. The series includes both heartwood and sapwood of all three species. The individual pieces have been inoculated with the most serious pine-destroying fungus. It is our expectation that the results from these inoculations will be ready for publication some time during the coming summer. While it is as yet too early to announce any definite conclusions, the indications from the blocks thus far removed from the series are that the resin content plays only a very minor part in determining the degree of decay-resistance.

Referring to the photographs submitted by Mr. Hoxie, there is doubtless a large number of pieces of pine that will decay provided they are placed under conditions which will favor rapid decay. The remedy in such instances will hardly be found in any specification either as to density or resin content. Where timbers, whether of pine or of any other class of wood, subject to rapid decay are used, the thing to do will be to preserve such timbers with any one of the well-known standard timber preservatives. I feel convinced that, if the new rule of the American Society for Testing Materials is applied, timbers will be obtained having high strength values; and if in addition to the new density specification the usual restrictions as to heartwood and sapwood are complied with, it will be found that as high a decay-resistance will be obtained for Southern yellow-pine timbers at the present time as has been in the past. It is absolutely essential, however, that specifications as to strength and heartwood and sapwood restrictions be included.

HERMANN VON SCHRENK.
St. Louis, Mo., Mar. 13, 1916.

Long-Range Weather Forecasts are claimed to be made possible by a new discovery announced by Dr. Willis L. Moore, of Rockville, Md., who was for 18 years Chief of the United States Weather Bureau. Dr. Moore is Professor of Applied Meteorology at George Washington University and has been engaged in research since leaving the Government service, in coöperation with W. F. Carothers, of Houston, Tex., and W. C. Abbott, of the Smithsonian Institution. The discovery referred to is that there are rifts in the upper clouds of the solar atmosphere which cause variations in the amount of heat radiated to the earth. These rifts in the solar clouds persist at times for many months, and the investigators have discovered the period of time between the passage of a heat rift in the solar atmosphere and the appearance of resulting storms on the earth. It is claimed that by this system weather forecasts can be made with reasonable accuracy for two weeks in advance.

Engineers' Qualifications and Technical Education*

By A. Marston†

The present-day problem in engineering education is how to educate our engineers better in the fundamentals of successful manhood without sacrificing the quality of their technical education. High qualities of manhood are absolutely essential in the engineer; so are high technical qualifications. Neither of these can be sacrificed to the other. The engineer must pass a double test and not fail in either manhood or technical requirements, just as the officer in the army must pass both a physical and a mental examination and would be rejected for failure in either.

Prof. C. R. Mann is making an investigation of engineering education in the United States, working under the auspices of committees of the Society for the Promotion of Engineering Education and of the other national engineering societies, but at the expense of the Carnegie Foundation. He has proposed a score-card for engineers, on the general plan of those used for live-stock by our agricultural friends, in which definite values are assigned on the scale of 100 to each of six qualifications, as follows:

Character	41.0
Judgment	17.5
Efficiency	14.5
Understanding of men	14.0
Total general	87.0
Knowledge of engineering science	7.0
Technique of practice and business	6.0
Total technical	13.0

The proposed score-card leads to absurd results when we attempt to use it as an actual guide in selecting the best men to fill engineering positions. As a state highway commissioner and as a dean of engineering my duties require me to determine the competency of engineers to fill about 200 responsible engineering positions. I have tried to apply the proposed score-card to a comparison of three moderately successful engineers of my acquaintance with three first-class business men of practically no engineering skill. The results are shown in the accompanying table.

RATINGS OF BUSINESS MEN IN COMPARISON WITH MODERATELY SUCCESSFUL ENGINEERS FOR APPOINTMENT TO ENGINEERING POSITIONS

		Moderately Successful Engineers						Successful Business Men					
	Perfect Engineer	City Engineer (5,000) Population		Railway Assistant Engineer		Engineer in General Practice		Prominent Grocer		Prominent Clothing Merchant		Prominent Banker	
Items	%	%	Credit	%	Credit	%	Credit	%	Credit	%	Credit	%	Credit
Character	100	78	41.0	80	32.0	76	32.8	90	31.2	93	36.9	93	38.1
Judgment	100	75	17.5	75	13.1	75	13.1	91	13.1	93	15.9	95	16.3
Efficiency	100	83	14.5	87	12.0	87	12.6	80	12.6	95	11.6	93	13.8
Understanding of men	100	75	14.0	73	10.5	78	10.2	90	10.9	93	12.6	97	13.0
Engineering science	100	86	7.0	84	6.0	83	5.9	10	5.8	5	0.7	10	0.4
Engineering experience	100	85	6.0	85	5.1	83	5.1	5	5.0	5	0.3	15	0.3
Total rating (on scale of 100)			100.0		78.7		79.7		77.6		80.2		81.9
													83.4

According to the proposed score-card, any really first-class business man ought to receive preference for appointment to engineering positions over any engineer of merely fair general qualifications, no matter how high the engineer's technical skill.

Future engineers cannot as a rule begin to acquire the necessary technical knowledge until they enter college. Hence, the effort of engineering schools is properly directed largely to imparting the necessary instruction in mathematics and the other sciences underlying engineering, in English, including public speaking, in political economy, in commercial and in technical subjects. The engineering schools may properly be held accountable for the thoroughness of this kind of engineering education, for they are the only agencies which supply it. The case is different with manhood qualifications, where many other agencies are involved.

No person should be ranked as an engineer who does not possess the manhood qualifications in satisfactory degree, and this requirement should be separate from and in addition to satisfactory technical qualifications.

From the educational point of view we should all recognize the indisputable fact that education in the fundamental qualities of manhood must extend through the entire life of each individual instead of merely through the few years he spends in college. The college should fit into the general scheme of development and should do its full share of the work, consciously, systematically and energetically. However, we should candidly face the fact that the engineering schools alone can in the nature of things do only a comparatively limited part of the work of developing the fundamental manhood qualifications needed in engineers. The situation is entirely different from that of the imparting of fundamental technical training, which begins at college, whereas manhood training begins in babyhood and must be well advanced long before entrance to college.

The most important part of one's training in character, in thoroughness, in industry, in temperament, in culture and even in conserving health ought to be that which he receives at home. Our public schools, which the future engineer attends for twelve of the most formative years of his life, are also vital factors in his development. It is well known to college educators that the average American youth comes to college with many serious and almost ineradicable faults, due to vital defects both in our public schools and in our home training.

Suggestions for Bettering Technical Education

The bulk of the suggestions for improving engineering education made by men who are not themselves experienced engineering educators refer to minor changes wholly inadequate to produce much real effect. The present standard engineering courses are the product of 76 years of active experimentation and of earnest seeking for the best, and it will not be found easy to improve them. The average outside practitioner is just about as competent to advise what specific changes in engineering education should be made as the average engineering professor is to advise the practitioner just how to improve his work.

One man suggests that the end can be obtained by substituting some "general culture" work for "technical" work. Ten credit hours of such substitution would occupy only about eight-tenths of 1% of the average total working life up to graduation from college. It makes very little difference in his culture whether he devotes that much time to literature and philosophy or to railway administration and advanced highway engineering.

*Part of an address delivered before the Chicago alumni of Iowa State College.

†Dean, Division of Engineering, Iowa State College, Ames, Iowa.

In fact, advanced technical work is culture work, in the true sense, if it is rightly taught and rightly studied.

Another suggests that we give up our separate courses in civil, mechanical and electrical engineering and go back to the good old days of only one engineering course. This is asking engineering education to run backward, and he might as well make the same request to the Mississippi River.

If the engineering schools are to produce graduates of really broader training and more complete manhood development, they must employ powerful agencies really adequate to effect important improvements. No minor changes will answer. Three great improvements occur to me as possible:

1. I believe that organized, direct, personal acquaintanceship, instruction and inspiration of every engineering student by every member of a large faculty of strong, able and experienced engineers, outside of regular class lessons, would be an immensely powerful agency in training better men and better engineers. I believe that every engineering professor ought to be held directly responsible for this part of his duties no less than for his class work.

2. Colleges seem to be organized on the basis of the public school, whose schedule is arranged for the purpose of allowing plenty of playtime for growing children. When an engineer becomes an engineering professor, it is found that he needs three months' vacation per year instead of two weeks, and he is regularly scheduled for from two to three classes per day instead of eight hours' regular work. College students are not held to the strict accountability to which men and women in actual life are subjected. Great educational plants which cost millions of dollars lie practically idle for months every year.

Furthermore, hoary college traditions, such as that of the undesirability of afternoon recitations, prevent the use of expensive laboratories for more than a fraction of the time when college is actually in session. Despite the fact that many professors and many students work more hours per day than the average engineer in outside practice, I cannot help feeling that we ought to inquire seriously into the question of the possibility and advisability of reorganizing our college work on a business basis with 48 weeks of school per year. All college equipment should be used forenoon and afternoon every day in the week, so far as feasible. Regular schedules for professors and students should provide adequately and definitely for all their work, including the preparation of lessons and the grading of reports and papers. Such schedules should also provide for regular research by those professors who have the special ability and enthusiasm needed for research that is really worth while. The most important studies ought to be taught at least twice per year, so as to facilitate entrance in the spring as well as in the autumn. In such a college the students ought to be treated as immature men rather than as adolescent boys.

3. A great improvement might be effected, in my judgment, by requiring one or more years of actual engineering work outside of college immediately following the sophomore year. Nothing will do more to make men of students than to set them to work with men, under the strict discipline of actual business regulations. I believe that a student who takes at least a year of outside work prior to his junior year will get at least 33% greater benefit from his junior and senior work. In our civil-engineering course at Iowa State College we have practically required at least two summer vacations at actual engineering work of every student, since 1898, and we observe much benefit therefrom. A 48-week school year would permit requiring one year of outside work without necessarily postponing graduation.

So far the five- and six-year engineering courses have practically failed. There is only one exception known to me, and in that case the engineering school is so small and so recently established that its ultimate success must still be considered uncertain. Still, I cannot help believe that six years of work beyond the present high-school standard will ultimately be required for graduation in engineering, the same as in medicine and in law.

Details of a Model Concrete Road in Pennsylvania

The Pennsylvania State Highway Department is building a concrete road between the Cities of Easton and Allentown, a distance of about 12 mi. The work on this road was described by William B. Uhler, Chief Engineer of the State Highway Department, at the recent Pittsburgh meeting of the American Road Builders' Association. Some unusual features in concrete-road construction which have been adopted on this work were described by Mr. Uhler.

Instead of the usual wooden plank for the side forms, 6-in. steel channels are used. These are in 12-ft. lengths and are held in place by steel pins. As they suffer no deterioration in use, it is believed that they are more economical in the long run than wooden side forms.

Unless great care is taken in dumping the sand and stone on the subgrade in advance of the work, the material will under-run and wheeling some distance to the mixer becomes necessary. In order to avoid this, the plan was adopted of dumping the sand and stone at measured intervals along the road. Cement is stored in portable canvas sheds holding 90 sacks each and is thus protected from the weather until use. As fast as these sheds are emptied, they are moved to the front. An electric trolley line runs the whole length of the road under improvement and serves to bring supplies to the work. In delivering material to the mixer specially devised wheelbarrows are used, holding exactly 3 cu.ft., and these barrows are struck off level with a shovel after loading. The water is also measured, and the aim is to make the concrete stiff enough so that it will not settle down quite level when discharged from the mixer into the bucket or when emptied from the bucket on the subgrade.

Experiments have been made to determine the proper time for mixing, and as a result a mix of 1½ min. is required. In the experiments that led to this conclusion test cubes of concrete were made up from the batches mixed for different times. The test cubes were kept eight days and then broken. Cubes from a batch mixed 1½ min., the mixer making nine revolutions, showed 1,400 lb. per sq.in. The 1-min. mix, 17 revolutions, showed 1,587 lb. per sq.in. The 1½-min. mix, 26 revolutions, showed 1,924 lb. per sq.in. Tests were also made of batches mixed 2 min. and 3 min., but these lots did not show an increase in strength worth the additional time

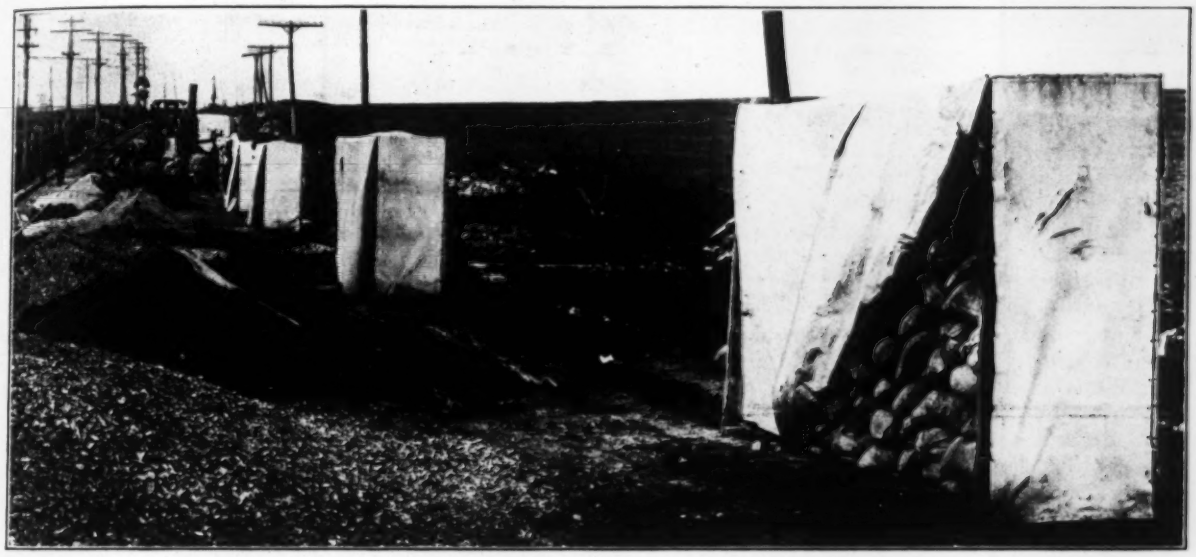
and cost involved. The test cubes made from the regular batches show a great variation in strength. In the 28-day tests, for example, the strength ranged from 2,362 lb. to 5,361 lb.

Before placing the concrete the subgrade is thoroughly wet and the concrete, which is mixed in proportions of 1:2:3, is placed to a depth of 6 in. at the side and 8 in. at the center. A heavy strike-board is then used to compact the concrete and give the road its proper form, and this board is followed by a lighter one. When the strike-board comes within 3 ft. of a joint, it is lifted and placed alongside the joint. Work then proceeds away from the strike-board. After water disappears from the surface of the concrete, it is floated smooth with a wooden float. Transverse joints are placed 36 to 40 ft. apart and consist of a ¼-in. thick prepared bituminous material 9 in. wide. Part of the bituminous strip above the surface is sheared off after the concrete is placed, leaving it projecting about 1 in. above the finished surface. This part is flattened down by traffic and protects the joint. A split float is used to finish the concrete on each side of the joint, so that both sides will be at the same elevation. The edges of the joint are rounded with a $\frac{3}{16}$-in. edger. The sides of the roadway slab are rounded with a ¾-in. edging tool.

Concerning the use of metal protection plates and of reinforcement in the road, Mr. Uhler says:

> There is a vast difference of opinion as to the advisability of using steel protection plates at the joints. Experience leads me to believe that, if proper care is taken in the maintenance of the unprotected joints, built as outlined herewith, far more satisfactory and economical results will be attained than by the use of steel joints, especially if there is any difference in the rate of wear of the concrete and the steel in the joints. Only a thousand feet of this road has been constructed with steel protection joints, and up to the present time no advantage in this method of protection is noticeable.
>
> The road in question is reinforced also with a light metal fabric, which is shipped to the job in sheets 5 ft. in width and 6 ft. and 10 ft. in length. This fabric is placed with longitudinal joints staggered and with a lap of 4 in. crosswise and 12 in. longitudinally. Of course, it would be preferable if sheets could be obtained the full width of the roadway. Reinforcing shipped in sheets, in my opinion, is more satisfactory, because it is easier to handle and can be installed with less trouble, while with rolled reinforcement there is bound to be more displacement of the concrete when the workmen endeavor to force it into place.
>
> This metal reinforcement is placed 2 in. below the top of the slab. It reduces the number and size of the cracks and is designed also to overcome longitudinal cracks that may occur because of the settlement of the shoulders.
>
> Throughout the West the general practice is to build concrete roads, without reinforcement, 6 in. at the side and 8 in. in the center. Personally, I believe that far better results can be obtained at the same cost, and under some conditions at less cost, by the construction of 5-in and 7-in. concrete roads with light metal-fabric reinforcement.

To protect it from the sun and air while it is setting, the concrete is shaded with canvas. Portable forms are used, which are set along the edges of the pavement and project about 12 in. above it. The canvas sheets are mounted on rollers laid on these forms and unrolled. After the concrete has hardened, the canvas is removed and the pavement is covered with two or three inches of earth and kept wet 10 to 14 days, when the road is opened to traffic. About 3¼ mi. of this road was completed last season, and thus far only two slight cracks have appeared.



PORTABLE CANVAS-COVERED CEMENT SHEDS USED ON EASTON-ALLENTOWN CONCRETE ROAD CONSTRUCTION

Mountain-Road Concession in Peru—The Peruvian Government has granted a concession to Adolfo Hilfiker, a civil engineer, for the construction of a pack road between the station of Urcos, on the Juliaca-Cuzco Ry., and a navigable point on the River Querene, or the River Madre de Dios, according to "Commerce Reports" of Apr. 6. The road will be approximately 125 mi. long and 8 ft. wide and will pass through native forests in which ample spaces must be cleared. Where swamps are encountered, they must be drained and a stone roadway laid. Bridges must be built over streams, or rafts and canoes provided. The concessionaire agrees to construct way stations or roadhouses every 15 mi., where carriers and freight may be protected from the mountain storms. Freight in transit may be stored at these stations without charge for 10 days or less. A telegraph and a telephone line must also be installed along the road, and electric communication must be furnished free to the Government. No toll will be collected for the use of the road. The concessionaire agrees to keep the road in repair for 30 yr., and at the end of this time to turn it over to the Government of Peru. In consideration of these various services the Government grants to Mr. Hilfiker the absolute ownership of 2,471 acres of mountain land for every 0.62 mi. of road constructed—a total of nearly 500,000 acres. Furthermore, the Government agrees to grant no concession for competing roads within 15 yr. Plans were required to be presented early in April, and the road to be completed within four years.

News of the Engineering World

Proposed Belt Railway for Boston District

A Terminal Commission appointed recently by the Massachusetts General Court (legislature) has reported certain conclusions and recommendations to the General Court bearing on the question of how Boston can improve its freight handling. The financial paralysis of the railways of that part of the country is held to justify terminal construction by the city.

The commission (1) suggests prompt action in making connection between the Union Freight Ry. and the South Boston yards of the New Haven; (2) calls for study by the Public Service Commission of delays in freight houses and of the effect of varying switching charges on the handling of freight; (3) recommends reconstruction of the Atlantic Ave. elevated structure for operation of railway cars to give a freight connection between North Station and South Station; (4) urges that the possibility of coöperation between street railways and the main-line railways in the matter of freight handling be studied, and most important of all (5) recommends the organization of a municipal corporation to construct and operate a belt-line railroad from the Boston & Maine north of the city of Boston, passing through Saugus, Revere, Malden, Everett, Chelsea, Medford, Somerville, Arlington, Cambridge, Belmont, Waltham, Watertown, Newton, Weston, Wellesley, Needham, Boston, Dedham, to a point near Readville on the New York, New Haven & Hartford R.R.

The latter recommendation did not have unanimous support in the commission, one member dissenting from the belt-line proposal and preferring a lighterage system to be developed by the railroad companies to reduce the terminal congestion. However, the commission finds that its other recommendations will not eliminate congestion and concludes that the only way to deal with this is to provide connection between the different railways through a belt line. Edward J. Dunn is secretary of the commission. Senator James F. Cavanagh is chairman.

Mechanical Engineers Meet at New Orleans

The spring meeting of the American Society of Mechanical Engineers was held Apr. 11 to 14 at New Orleans, La. Special cars were run from Chicago and New York; and those traveling by these cars spent Monday at Birmingham, Ala., where the visitors were entertained by the Birmingham section of the society with an all-day excursion to the Thomas furnaces of the Republic Iron and Steel Co., the Ensley blast furnace and steel plant and the Edgewater coal mine of the Tennessee Coal, Iron and Railroad Co., the Fairfield byproduct coke plant of the same company and the Fairfield mills of the American Steel and Wire Co. A barbecue was served at Bayview on the shores of the artificial lake, six miles long, created by the Tennessee company to maintain the water-supply for its properties.

At New Orleans the excursions to various points of interest were an even greater attraction than the professional sections. An especially interesting visit was that to the new drainage-pumping stations, where are installed the new electric motor-driven screw pumps invented by A. B. Woods, which were described in *Engineering News* of Jan. 13, 1916.

On Wednesday afternoon the visitors were taken by river steamer along the entire waterfront of the city and spent an hour inspecting the new reinforced-concrete cotton warehouses built and operated by the New Orleans Port Commissioners and described in *Engineering News* of June 24, 1915.

Thanks to the inheritance from the French system of jurisprudence, the State of Louisiana has retained in public ownership the entire waterfront of the Mississippi River at New Orleans. These great cotton warehouses, which will cost when completed about $3,000,000, represent the first step in a planned system of public warehouses and shipping facilities for New Orleans. The second step in creating this system is a reinforced-concrete grain elevator of 1,000,000-bu. capacity, the construction of which has begun. Both these works have been designed by, and are being erected under supervision of, the engineering firm of Ford, Bacon & Davis.

Thursday afternoon was devoted to an excursion to a typical land-reclamation enterprise near New Orleans. During the last ten years the drainage of swamp lands along the Gulf has been an important field of engineering work. Within the city limits of New Orleans a tract of 7,000 acres of land on the shores of Lake Pontchartrain has been drained by the New Orleans Lake Shore Land Co., and most of it has been planted with citrus fruits. This swamp land is claimed to be worth $500 to $800 or more when drained and improved, as it is marketable for country homes for residents of New Orleans.

The leading feature of the technical sessions held during the convention was a paper on "Organizing for Industrial Preparedness," by Spencer Miller, one of the society's representatives on the Naval Consulting Board. The paper reviewed what has been done by the National Engineering Societies—first, in the organization of the Naval Consulting Board and, second, in the plans for making an industrial census of the manufacturing plants of the country able to contribute to our military and naval supplies in the event of war. The discussion on this paper was fruitful in suggestions as to ways in which engineers might best contribute toward the work of national preparedness. Besides a large number of discussions contributed by absent members, there was such active debate by those present that it extended over the sessions of the convention.

The session on Thursday morning was devoted to three papers relating to fields of engineering in which New Orleans engineers are especially interested. E. W. Kerr, Professor of Mechanical Engineering of Louisiana State

University, described some tests on multiple-effect evaporators used in sugar-making plants, in plants for water distillation, etc. The university has long specialized in giving instruction in the field of sugar machinery, and its graduates have been prominent in the sugar industry, both in Louisiana and in Cuba.

Prof. William B. Gregory, Tulane University, described "The Evolution of Low-Lift Pumping Plants on the Gulf Coast" in connection with land-drainage enterprises; and William von Phul, New Orleans, a member of the firm of Ford, Bacon & Davis, reviewed the mechanical devices used in handling freight, etc., in the Port of New Orleans.

On Friday morning the convention closed with two simultaneous sessions. In one session three papers on measurements of fluid flow were read. The first two papers referred to the measurement of natural gas and the third, by Prof. Horace Judd, Ohio State University, described experiments on the flow of water through orifices. In the other meeting, papers were read on "Dynamic Balance" by N. W. Akimoff, on "Viscosity Measurement" by H. C. Hayes and G. W. Lewis and on "Heat Transmission in Boilers" by E. R. Hedrick and E. A. Fessenden.

Panama Canal Reopened

The Panama Canal was officially reopened, to vessels drawing up to 30 ft. of water, on Apr. 15 after being closed seven months on account of slides in Gaillard Cut. The present slides started Sept. 18, 1915, and closed the canal for about half a mile along the deep cut. It was estimated that about 10,000,000 cu.yd. of rock would have to be taken out to bring the canal back to its original section. While all this has not yet been removed, the dredges working in the slide have maintained the remarkable average of over a million yards per month.

Engineers in Preparedness Demonstration

The 3,000-odd engineers who have been attending military lectures in New York City under the auspices of four national engineering societies will form a division in a parade to be held in New York on May 13 as a public demonstration in favor of a national preparedness program. An effort will be made to ask the participation of every engineer in the metropolitan district, and in addition a blanket invitation has been issued by the secretary of the lectures committee, J. S. Langthorn, 250 West 54th St., New York City.

The engineers' division of the parade will be made up of four general subdivisions—civil, mining, mechanical and electrical. These subdivisions are made for convenience in organization and are not in any sense representative of any engineering society. Engineers are invited to parade as engineers, whether they are members of any organization or not. But any affiliated branch or society which so desires and whose numbers warrant will be assigned to a separate subdivision. For the organization of the engineer division the secretaries of the four national societies have been named as subcommittees.

The studies of the New York engineer group are being continued by readings and *conversazioni*. The topic for the meeting of Apr. 24 (Engineering Societies Building, 8:15 p.m.) is "The Psychology of Discipline"—a lecture by Maj. Gen. J. F. O'Ryan; on May 8, infantry-drill and field-service regulations, and combat methods of the present war will be discussed; on May 22, the topics will cover field fortifications, engineer field manual and Atlantic Coast defense.

Conference on Engineering Co-operation at Chicago

The outcome of the second Conference on Engineering Coöperation, held at Chicago on Apr. 13 and 14, was the establishment of a subcommittee to prepare a plan for forwarding coöperation among engineering societies upon matters of general interest to the profession. The chairman of this subcommittee is to be F. H. Newell, head of the civil-engineering department at the University of Illinois, and the other four members are to be selected by him. Its plan will be presented for consideration at a third conference, which is to be called by the subcommittee when it is ready for such action. The several organizations represented at the meeting will be invited to assist in defraying the expense of the work.

This was the logical outcome of the meeting; for while all those in attendance agreed upon the general principle that "something should be done," the majority had no definite ideas as to what should be done, and the few individual opinions did not receive much support.

The conference was attended by about 30 persons representing more or less officially 42 national, state and local societies and organizations. All the large national societies were represented by delegates, except the American Society of Civil Engineers, a fact that stirred up some strong comment. The preamble to the resolutions adopted set forth that the rapid increase in engineering activities in recent years has given rise to many problems vitally affecting the practice of engineering, while existing agencies (owing to lack of proper coöperation) appear inadequate for the solution of these problems. "This subcommittee is established therefore," the statement read, "in order that the resources of the profession may be made available for the most useful service to the nation, state and municipality and in order that the practice of engineering may be rendered more efficient and less burdensome in those places where its development has been most difficult." It was the sense of the meeting in adopting the resolutions that these ends may be attained through a closer association and coöperation of engineering societies.

A plan for two great engineering organizations was suggested by Paul Hansen, Chief Engineer of the Illinois State Board of Health, one of these to represent state and sectional societies and the other to represent the national societies. Another suggestion was for a single representative organization, but it was shown to be out of the question to expect the large national societies to become subordinate to or units in such a comprehensive organization, including societies and men of any and all grades of professional and semitechnical qualifications. Gardner S. Williams, consulting engineer, Ann Arbor, Mich., advocated consolidation rather than coöperation among a number of separate organizations. He suggested one great engineering association that would represent the body of engineers and not the engineering societies.

Elmer Corthell, President of the American Society of Civil Engineers, sent a letter urging that coöperation should come through action of the existing societies and not through the present independent movement. There seem to be no indications, however, that coöperation will ever result in this way, and it was the general opinion that work should begin at the bottom and not at the top. H. C. Gardner, Chicago, representing the American Society of Mechanical Engineers, objected to the formation of a new or separate society.

Isham Randolph, consulting engineer, Chicago, thought that, while there are too many societies, it is out of the question to think of combining the national societies. He suggested, as the spirit of the meeting, that there should be a central organization in the interest of the common good. This should have no authority to command, but should serve as an ear to receive any plea or promise and a mouth to make any such communication known to all affiliated bodies. Its activities should include also a general annual meeting of a social nature. This idea was received warmly, as indicating an altruistic attitude for coöperation rather than a more limited professional attitude.

The score of papers and addresses presented at the five sessions represented a wide range of subjects. Chairman Newell suggested that the three special lines of activity should be publicity, employment and legislation; that is, informing the public what engineering is and does, helping the engineer to progress in his life's work and supporting or opposing legislation on matters affecting both engineering and public policy. John Howe Peyton, Engineering Association of the South, considered that one important object of coöperation is to secure public recognition and appreciation of the engineering profession.

Willard Beahan, Cleveland Association of Members of the American Society of Civil Engineers, thought that local sections of the national societies should not be in leading strings held by the latter, but should be trusted with freedom of action. H. C. Gardner, Chicago, stated that the American Society of Mechanical Engineers has sections in 15 cities, with others in contemplation. The society has a conference of section delegates at each annual meeting and grants appropriations to cover certain expenses of the sections.

The German system of a central organization with a council of delegates from district organizations was outlined by A. W. Hoffman, Chicago. In this case, however, all the separate organizations are on the same professional plane, and the system could not be applied to a control of the various and heterogeneous engineering bodies in this country. The activities and coöperation of local societies at Cleveland, St. Paul, St. Louis and Philadelphia were outlined by different speakers. C. E. Drayer, secretary of the conference, gave an illustrated talk on the publicity methods of the Cleveland Engineering Society, whereby the local engineers and their works are brought into public notice through newspaper articles and like means.

The coöperative activities in these cities cover social and public or municipal affairs as well as technical matters. In fact, one strong point made throughout the conference was that the engineer and the engineering society should give much more attention to the human or social element and to politics and matters of public policy.

New Building Code of New York Is Published

The new building code of New York City, prepared during the past two years by sectional revision by E. P. Miller, has just been issued in printed form. It covers the full range of the old code, except for the omission of certain parts which formerly overlapped state laws.

One important change is yet to be made in the code: The theaters section is still to be revised and will then be issued as a separate publication. The present book—a 4½x7½-in. volume of 278 pages—includes the old section, with minor editing carried out last year.

The Bureau of Buildings, Manhattan, is headed by Alfred Ludwig, Superintendent. A full index is appended to the book, an important feature, as few building codes are decently indexed.

St. Paul Adopts Electric Pumps

The St. Paul (Minn.) Bureau of Water on Mar. 27 received bids for two motor-driven centrifugal pumps, each of 6,000,000-gal. daily capacity. The Northwestern Electric Equipment Co. was the low bidder at $7,688. This figure covers switchboards, instruments, etc. Estimated cost of station extensions is $7,500. On Mar. 20 the Northern States Power Co. bid to furnish power for pumping at $4 per million gallons against 158.5-ft. head. The head is actually from 146 to 171 ft., and the quantity now varies from 6.8 to 9.7 million gallons' daily average, depending on the season. The pumps will not be operated between 4 p.m. and 7 p.m. during November, December, January and February. The efficiency of the pumps is to be approximately 72%. The efficiency and average head are to be determined each month, and the normal price of $4 corrected for deviation from assumed values.

These pumps are to be placed in the McCarron station, where added capacity has been desired for several years. At first it was purposed to install a 15,000,000-gal. triple-expansion unit at a cost of $96,500. In 1915, bids were invited on a steam-turbine driven centrifugal with reduction gears and on a triplex plunger pump driven by triple-expansion vertical engine, but bids were received on the centrifugal only. Finally it became apparent that electric centrifugal pumps would be economical in fixed charges and needed only a low power rate for operation. This it was aimed to secure by off-peak operation—the price bid corresponding to about 6 mills per kw.-hr. The Water Department has adequate reservoir capacity for the "high-gravity service" to be supplied.

Augusta To Have Building Code

Following the recent fire at Augusta, Ga., which did damage of $6,000,000, the City Council ordered that no building permits be issued until a new building code could be adopted. A subcommittee that was appointed has recommended the adoption of the code of the National Board of Underwriters. The council will establish a fireproof district containing the greater part of the business section. The use of shingle roofs is to be absolutely forbidden, and it is provided that at the end of ten years every roof at present of this material must be changed to one of noncombustible covering.

As soon as possible after the fire the city-engineering department dynamited about fifty walls that were left

standing in the burned area and were dangerous to passersby. Among buildings announced to be rebuilt are St. Paul's Church (which will cost about $75,000), the home of the Augusta *Chronicle* and the Southern Cotton Oil Co.'s warehouse.

The J. P. Berckmans Co., landscape architect, has offered to coöperate with the city in planning the business district and the part of the residence section that was burned. The offer has been accepted by the council; this work will be without remuneration. A rebuilding commission, composed of this firm and local engineers and architects, is to be appointed to supervise the work of reconstruction.

Syracuse Grade-Crossing Elimination Plans

The removal of the New York Central tracks in Syracuse, N. Y., at grade on a long stretch of Railroad Ave. and at various crossings has been sought for years by the city, the favored plan being to utilize the bed of the old Erie Canal, which will be abandoned when the new State Barge Canal is placed in service. To this end the so-called Walters bill was passed by the State Legislature, providing, by amendment to the Public Lands Law, a method for disposing of abandoned canal lands. One section sought to enable the state to convey to the City of Syracuse so much of the abandoned canal lands as might be required to give a depressed route across the city, this to be a part of the state's share in the cost of eliminating grade crossings as contemplated by the Railroad Law. The Governor, however, vetoed the measure on the grounds that it would violate the Canal Referendum Act and divert canal funds to grade-crossing elimination—the act not being amendable in this respect.

The same bill, introduced without the objectionable section, has been passed and is before the Governor. It gives the City of Syracuse a preferential right to acquire the old canal bed at a valuation fixed by the Land Office Commissioners. The canal runs almost parallel to the present tracks and offers an admirable railway right-of-way.

ENGINEERING SCHOOLS

Massachusetts University Extension

The University Extension Department of the Massachusetts Board of Education, established under authority of the legislature in 1915, has announced its first courses. No tuition fees are charged, but students have to pay the cost of books, pamphlets, stationery, postage, etc. Only one course may be taken at a time. Most courses consist of 20 lessons, each designed to require 6 to 12 hr. study. One year is allowed for each course. Certificates of completion are to be issued after examination. The ground covered includes:

1, Language—English and commercial Spanish; 2, American history and civics; 3, economics and sociology; 4, commercial practice—bookkeeping, correspondence, industrial management, selling; 5, drawing—mechanical drawing, sketching, descriptive geometry and machine design; 6, engines and boilers and heating, ventilating and power plants; 7, practical electricity; 8, structural, highway and hydraulic engineering—materials of construction, elements of structures, highways, steel-building and bridge design, reinforced concrete, hydraulic theory, water-supply and irrigation.

NEWS NOTES

Municipal Ownership of Water-Works at Everett, Wash., is assured by an agreement reached on Apr. 11 between the city and the Everett Railway, Water and Light Co. The city will take possession of the works on Aug. 10 for $994,000, or $97,000 below the estimate made by Burns & McDonnell, of Kansas City, Mo. The city has already voted and contracted for the sale of $1,700,000 of water bonds, of which $600,000 is for a gravity supply from the Sultan basin. It is reported that Burns & McDonnell are engineers for the new supply.

The Use of Los Angeles Aqueduct Water by the San Fernando Irrigation District has been assured by the award to the Llewellyn Iron Works and to the Lacy Manufacturing Co. of contracts for about $266,000 worth of steel pipe for the beginning of a distribution system. The district voted $2,604,000 for the distribution system in 1913. Since then, as was tacitly agreed in advance, the most of the 85,000 acres within the district has been annexed to Los Angeles. The construction work will be done by the Public Service Commission of Los Angeles, under the direction of Wm. Mulholland as consulting engineer.

A Strike of Water-Works Laborers occurred recently at Cleveland. The new city charter provides for an 8-hr. day and $2.50 as a minimum wage for labor on work in which the city is interested to the extent of contributing money. Sewer contractors have consequently bid on this basis on new work since the charter went into effect, but it is stated that the city has not had sufficient funds to pay its laborers at the rate of $2.50 a day. The new Director of Public Utilities, T. F. Farrell, is said to be a labor-union man, but to have found it necessary to refuse the demands of the laborers for an increase in their wages.

A New Water-Works at Lagos, Nigeria, the construction of which was begun in October, 1910, is now almost complete. The town has a population of 75,000 and will be supplied from the Iju River. The pumping plant consists of two helical-geared triplex power pumps and three direct-acting pumps. The capacity of each set of pumps is 5,000-gal. per min. There are eight filters; each one is 7,360 sq.ft. or about one-sixth acre, in area, with a sand depth of 2½ ft. The distribution system will comprise about 28 mi. of mains, 200 four-way street fountains and more than 350 fire hydrants. The plant has a capacity of 2,250,000 gal. per day and is designed to supply 115,000 inhabitants. The cost will be about $1,500,000.

Eminent-Domain Proceedings to fix the value of public-utility property taken for municipal purposes in California are valid, according to a decision of the California Supreme Court. This decision was handed down in a case under which the State Railroad Commission had been asked by the Marin Municipal Water District to place a value on the property of the Marin Water and Power Co., which the district wished to take over. Similar proceedings to fix the value of water-company properties that San Diego and Santa Monica wish to take have also been instituted by the State Railroad Commission, and the City of Los Angeles has asked the commission to fix the value of the property of the Southern California Edison Co.

A Rear-End Collision on the New York, New Haven & Hartford R.R. occurred at Bradford, R. I., on Apr. 17, killing 6 and seriously injuring 41 persons. The head train was a local, which left Boston at 5:03 p.m. It had been delayed by difficulty in getting the locomotive to steam properly and was taking a siding at Bradford to let pass the so-called Gilt Edge express leaving Boston at 5:34 p.m. It is reported that a flagman had been sent back and that the home and distant signals were set against the express. Nevertheless, it passed the flagman and tore into the rear of the local, which had not cleared the main tracks. The two rear cars of the local were demolished and immediately took fire. The Bradford station was also burned down. At the investigation which followed the accident the towermen claimed that the signals were at "Stop," while the engineman of the express claimed to have seen "Clear."

Casualties on Steam Railways for the year ending June 30, 1915, recently published by the Interstate Commerce Commission, show a decrease from 1914 of 1,681 in the number of persons killed and of 30,622 in the number injured. The total number of casualties for the year was 170,661, of which number 8,821 were killed and 162,040 injured. This total includes 343 employees killed and 99,192 employees injured in what are known as industrial accidents; that is, where employees were killed on the premises but not in connection with train operations. Analysis of the figures shows that 2,152

of the killed were employees, 222 were pasengers, 5,084 were trespassers. For 1914 the corresponding figures were 265 passengers killed and 6443 trespassers.

Unanimity Among Engineers—While the engineering profession is concerned with the reason for the seemingly low estimate which the public in general sometimes places upon engineering advice, we overlook the fact that our own members frequently manifest a surprising lack of confidence in the opinions of their associates on common subjects of engineering discourse. If, therefore, we are ever to expect a respectful recognition on the part of the public of the right of engineers to solve engineering problems, there must first come some indication of substantial unanimity among the members of the profession itself as to common engineering questions. I contend that this result can only be brought about through a thorough discussion between engineers of their many problems, aided by a presentation of the combined experience of all individuals who are in a position to contribute.—Presidential address of Charles R. Gow before Boston Society of Civil Engineers.

A Union Railway Terminal for Interurban Lines, with office building above, is being built for the Dallas Interurban Terminal Association at Dallas, Tex., by the Stone & Webster Engineering Corporation. The building will be 83x217 ft., with a structural frame of reinforced concrete, designed for a height of 11 stories. The exterior walls will be of pressed brick and terra cotta for the street sides and common brick for the rear and the temporary end. In the basement will be a substation for the Dallas Electric Light and Power Co. and a heating plant for the office building. On the ground floor will be waiting-rooms and other facilities of the terminal, with stores on the street fronts. Provision will be made for five elevators, also for vacuum-cleaning devices, telephone and call-bell systems, fire-alarm system, electric fans, refrigerating system for drinking water, and other service equipment. The work will include tracks and overhead work on the approaches and in the terminal proper. There will be concrete loading platforms in the terminal yard and a steel and concrete umbrella shed over the loading platform.

The New Water Intake at Milwaukee, Wis., will be modified from the original plans and will consist entirely of a tunnel with intake shaft at the lake end. The original design, described in "Engineering News," June 18, 1914, provided for a 12-ft. tunnel 4,000 ft. long with an intake shaft covered by a closed crib from which four lines of 6-ft. pipe were to be laid along the bed of the lake for 2,500 ft., ending in separate submerged intakes in deep water. On the recommendation of the Commissioner of Public Works, Fred G. Simmons, and after the approval of a board of engineers it was decided to extend the 12-ft. tunnel 2,500 ft. and to eliminate the pipe lines. At the end of the 6,500-ft. tunnel there will be a submerged crib, this intake being in about 65 ft. of water and 40 ft. below the surface of the water. The contract has been let for the tunnel extension. Work is in progress on the land tunnel running southwest from the new intake tunnel to the present North Point pumping station, which is on the lake shore and about a mile south of the new tunnel. Within the next few years a land tunnel will be built due west as an extension of the lake tunnel to a new pumping station on the Milwaukee River. The city has already acquired the site for this station.

Right to Buy the Plant of the Des Moines Water-Works Co. at a valuation of $2,302,550, fixed by appraisal as of Apr. 1, 1912, has been denied by the United States Circuit Court of Appeals. This denial affirms the decision of the District Court to the effect that failure of the city to take over the plant before Jan. 1, 1915, was to waive the rights of the city to purchase at the valuation named. The franchise of the company expired May 1, 1911, and in June, following, the people of Des Moines voted to buy the works. Three judges valued the plant as already stated. The company contested the valuation, and the Federal Court decided this suit in favor of the city. Three bond elections to provide money to take over the works have been held. At the first two of these there was an actual but not a statutory majority for purchase. The results of the third election were held in doubt, apparently for the same general reason as prevailed in the two earlier elections. The company contested the third bond lection, held in November, 1914. Its contention was overruled in the lower courts, but the case is still pending in the state Supreme Court. Meanwhile, according to the Federal decision just rendered, the rights of the city to purchase at the appraised valuation named were lost. J. R. Hanna is mayor of Des Moines, and C. S. Denman is manager of the Des Moines Water-Works Co. It is reported that the mayor has expressed the intention of the city to open negotiations for a new valuation and that Mr. Denman has said that the company is willing to negotiate.

Plans for More Niagara Power—On Apr. 13 Hon. J. R. Lucas, Attorney General of Ontario, introduced a bill in the Provincial Legislature providing for the development of additional electric power from the unallotted water at Niagara Falls, as recommended by the Ontario Hydro-Electric Commission last fall. He explained that the amount of water that can be used in Canada is limited by treaty to 36,000 cu.ft. per sec. Three companies already have concessions and are using about 28,000 cu.ft. of the total, so that only 7,000 cu.ft. is left available. Two of these companies claim that under their contracts there is no limitation as to the quantity of water they might use, but no one is willing to go on with the proposed power development at Niagara, at a cost of $10,000,000, until this point is settled. The Lucas bill gives the Government authority to say what amount of power a company might develop; and if any objection is raised, there will be a reference to a commission to be named by the Government to determine whether the company has the right to develop more than the limit. If it is found that the companies' rights have been taken away, compensation will be given them. Another bill was introduced ratifying contracts entered into by the municipalities interested in the scheme for a radial hydro-electric railway between Toronto and London. Attorney General Lucas stated that it is out of the question to proceed with this work during the continuance of the war; it might, however, be expedient in the meantime to purchase or secure options on the right-of-way.

PERSONALS

Mr. Caleb Berry has been appointed City Engineer of Centralia, Wash.

Mr. Thomas G. Bush has resigned as Assistant State Highway Commissioner of Washington.

Mr. R. J. Palmer will succeed Mr. L. L. Kelley as Resident Engineer of the Norfolk & Western Ry., at Norfolk, Va.

Mr. Frederick S. Strong has resigned as Division Engineer of the New York State Highway Department at Hornell, N. Y.

Mr. C. S. Woodward has resigned as Road Engineer of Jessamine County, Kentucky, after holding that office for nearly five years.

Mr. L. L. Kelley, formerly Resident Engineer of the Norfolk & Western Ry., at Norfolk, Va., will succeed Mr. W. P. Wiltsee as Assistant Engineer.

Mr. Charles L. Wallace, Valuation Engineer of the Texas & Pacific Ry., has been appointed Assistant to the Vice-President, with headquarters at Dallas, Tex.

Mr. W. P. Wiltsee, Assistant Engineer, at Norfolk, Va., of the Norfolk & Western Ry., has been appointed Assistant to the Chief Engineer, with office at Roanoke.

Mr. H. L. Dougherty, who has been in the service of the Pennsylvania State Highway Department since 1912, has been appointed Superintendent of Highways in Washington County.

Capt. Robert M. Carswell has resigned from the Engineering Department of the City of Wilmington, Del., to join the engineering staff of the E. I. du Pont de Nemours Powder Co.

Mr. Francis W. DuBois, recently United States Surveyor in the General Land Office at Little Rock, Ark., announces his partnership with H. L. Cory, Baker, Mont., with offices in Baker.

Mr. Samuel A. Green, who has been in the Baltimore County (Md.) road department for the past seven years, has been appointed Assistant Engineer to fill the vacancy caused by the recent resignation of H. O. Halbert.

Mr. Edwin S. Pearce, Jun. Am. Soc. M. E., Special Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Ry., at Indianapolis, has been appointed Assistant Mechanical Engineer, with headquarters at Beech Grove, Ind.

Mr. J. M. Fine, who has been for eight years Mechanical and Electrical Superintendent in the Northern Division of the United States Reclamation Service, has resigned to enter the electrical department of the Anaconda Copper Mining Co.

Governor Bilbo of Mississippi has appointed the following members of the newly created State Highway Commission: Messrs. J. M. McBeath, Lauderdale, two years; D. W. Robbins, Lee County, four years; and J. T. Denman, Pike County, six years.

Mr. Willard A. Stockbridge, Assoc. Am. Inst. E. E., Electrical Engineer of the Northwestern System of the Pennsylvania lines, at Fort Wayne, Ind., has been appointed Electrical Engineer in the office of the General Superintendent of Motive Power, at Pittsburgh, Penn.

Mr. J. L. Bradford, who recently resigned his position as Bridge Designer with the New York State Barge Canal, at Albany, N. Y., has accepted a position with the American Bridge Co., Pittsburgh, Penn. He will be located at the company's Ambridge (Penn.) plant.

Mr. Frank H. Shaw, Assoc. M. Am. Soc. C. E., Consulting Engineer, Lancaster, Penn., has opened an office at 2307 Woolworth Building, New York City, in addition to his Lancaster office. He will handle the design and construction of water, gas, sewerage and hydro-electric installations.

Mr. Charles P. Light has severed his connection with the American Highway Association as Field Secretary. He will associate himself with the Fidelity Mutual Life Insurance Co. of Philadelphia in a managerial capacity. After May 1 his offices will be at 1423 G St., N. W., Washington, D. C.

Mr. Reid Jones, Assoc. M. Am. Soc. M. E., has resigned as Designing Engineer of Bartlett & Ranney, Inc., Consulting Engineers, San Antonio, Tex., to form a partnership with C. S. Thomas, Jr., St. Louis. The firm, under the name of Thomas & Jones, will conduct a general engineering and contracting business, with offices in the Chandler Building, San Antonio.

Mr. Lynn Crandall, Assoc. M. Am. Soc. C. E., Assistant Engineer of the United States Geological Survey at Salt Lake City, has resigned to accept the position of Chief Hydrographer of the Twin Falls North Side Land and Water Co., Jerome, Idaho. Mr. Crandall will have charge of extensive hydrometric investigations to be conducted during the present irrigation season.

Mr. Francis M. Veatch, Jun. Am. Soc. C. E., who has been since his graduation from the University of Kansas in 1913 employed by the Chemical Research Division of the university, has been elected Assistant Engineer of the Kansas State Board of Health, to succeed Mr. F. R. Hesser, resigned. Mr. Veatch in connection with his work at the university has investigated the operation of sewage-disposal plants in Kansas.

Mr. C. A. Johnson, who for the past eight years has been Associate Professor of Electrical Engineering at the University of Kansas, has resigned to enter the switchboard department of the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn. Mr. Johnson graduated from the University of Nebraska in 1906 and spent two years with the Westinghouse company before taking up work at the University of Kansas.

Messrs. Carl R. Camp and Albert W. Zahniser have incorporated the firm of Camp & Zahniser, Inc., Engineers and Contractors, with offices in the Crozer Building, Philadelphia, Penn. The company will do general contracting, giving particular attention to concrete and steel structures. Mr. Camp, who will act as President, has been a contractor for several years; Mr. Zahniser, the Secretary-Treasurer, has been with the Guerber Engineering Co., Bethlehem, Penn., and the Carnegie Steel Co., at Newark, N. J.

Mr. Paul Gendell, Manager of the Engineers' Society of Pennsylvania, at Harrisburg, has resigned to become Secretary of the Dubois (Penn.) Chamber of Commerce. Previous to his managership of the society Mr. Gendell had been connected for ten years with the engineering department of the Bridge and Construction Department of the Pennsylvania Steel Co., Steelton, Penn., and before that was an Assistant Engineer of the Missouri Pacific System. As Manager of the society he was also editor of its engineering journal.

Mr. Eric T. King, Assoc. M. Am. Soc. C. E., for the past ten years an Assistant Engineer, New York City Board of Water-Supply, has resigned to become assistant to Lederle & Provost, Sanitary Experts and Consulting Engineers, New York City. Mr. King graduated from Union College in 1905 and after graduation spent six months with the United States Geological Survey on river-control studies in Oklahoma and several months following as Water-Supply Engineer with the New York State Department of Health. Since then he has been engaged on the preliminary work and construction of various portions of the Catskill Water-Supply System for New York City, including the siphon tunnel under the Hudson River, steel and cast-iron pipe lines and Silver Lake Reservoir.

Mr. Harrison G. Roby, formerly in the consulting-engineering offices of Prof. D. W. Mead, Madison, Wis., and in that connection engaged as superintendent on the construction of the Alpena (Mich.) Power Co.'s dam, has been appointed City Manager of Alpena, with an annual salary of $2,500. After the completion of the dam in 1910 Mr. Roby was superintendent of construction at Iron Mountain (Mich.) for the Oliver Mining Co., having charge of the building of a 6,000-hp. dam at that place. While at Iron Mountain he was also engaged as City Engineer, during which time he built an incinerator and a bridge and did much pavement and sewer work for that city. Mr. Roby graduated from Dartmouth College in 1904 and spent the two years following in Wyoming on railroad construction. In 1906 he entered Thayer School at Dartmouth. After securing the C. E. degree he was engaged by the McCall Ferry Power Co., having charge of a party in locating transmission lines from a water power on the Susquehanna River.

Messrs. August E. Hansen and Waldo S. Coulter, Assoc. M. Am. Soc. C. E., have formed the firm of Hansen & Coulter, with offices at 2 Rector St., New York City, and will act as designing, consulting and superintending hydraulic and sanitary engineers in the lines of water-supply and water purification, water-power developments, sewerage and sewage treatment, sanitation of buildings, garbage disposal and river improvement. Mr. Hansen is a graduate in sanitary engineering of the Massachusetts Institute of Technology and has been associated for the past nine years with Lederle & Provost, New York City. Previously he was for five years Assistant Engineer with Andrew D. Fuller, Consulting Sanitary Engineer, Boston; treasurer of the E. M. Porter Plumbing and Heating Co., Springfield, Mass.; Principal Assistant Engineer with W. P. Gerhard, Consulting Sanitary Engineer, New York City, and Engineer in Charge of Construction with Williams, Proctor & Potts, Consulting Hydraulic and Sanitary Engineers, New York City. While with Lederle & Provost he was in Argentina, supervising work on treatment plants for slaughter-house, wool-scouring and tannery wastes at Buenos Aires. For four years he was in charge of the designing room of the Bureau of Rivers, State Barge Canal, Albany, N. Y. At various times he has been employed upon the design of the New York City subways, the construction of the Interstate canal and Pathfinder dam in Wyoming and Nebraska and was employed for seven years by the Metropolitan Water and Sewerage Board of Massachusetts.

OBITUARY

Edward L. Wagner died at his home in Plainfield, N. J., on Apr. 14, at 32 years of age. Mr. Wagner graduated from Princeton University in 1909, since which time he had been employed in New York City as a structural steel engineer.

William F. Frey, a well-known contractor in Indiana, died suddenly at Lafayette on Mar. 31. Mr. Frey was at one time president of the Business Men's Club of Lafayette and served for three years as president of the public school board of that city.

William R. Thomas, Mechanical Engineer, Catasauqua, Penn., died at his home in that city, on Apr. 13, at 88 years of age. He was born at Glamorganshire, Wales. He assisted in building the Illinois Central R.R. and later for some years operated iron works in the South. Mr. Thomas received one of the first patents ever issued for a gas engine and also held patents for milling, furnace and automobile machinery.

ENGINEERING SOCIETIES

COMING MEETINGS

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS.
Apr. 26-27. One-hundredth annual meeting in Boston. Office of secretary, 45 Milk St., Boston, Mass.

AMERICAN ELECTROCHEMICAL SOCIETY.
Apr. 27-29. Annual meeting in Washington. Secy., J. W. Richards, Lehigh University, South Bethlehem, Penn.

AIR BRAKE ASSOCIATION.
May 2-5. Convention in Atlanta. Secy., E. M. Nellis, 53 State St., Boston.

CANADIAN RAILWAY CLUB.
May. Annual meeting in Montreal. Secy., James Powell, P. O. Box 7, St. Lambert, near Montreal.

RAILWAY DEVELOPMENT ASSOCIATION.
May 9-11. Annual meeting in New Orleans. Secy., H. O. Hartzell, B. & O. R.R., Baltimore, Md.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 9-11. Annual meeting in Chicago. Secy., Franklin H. Wentworth, 87 Milk St., Boston.

AMERICAN SUPPLY AND MACHINERY MANUFACTURERS' ASSOCIATION.
May 10-12. Convention in Pittsburgh. Secy., F. D. Mitchell, 1510 Woolworth Building, New York City.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
May 15-18. Annual meeting at Hotel Sherman, Chicago. Secy., J. G. Crawford, 702 East 51st St., Chicago.

NATIONAL DISTRICT HEATING ASSOCIATION.
May 16-19. Eighth convention in New York City. Secy., D. L. Gasgill, Greenville, Ohio.

SOUTHWESTERN ELECTRICAL AND GAS ASSOCIATION.
May 17-20. Annual convention in Galveston, Tex. Secy., H. S. Cooper, Slaughter Building, Dallas, Tex.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
May 22-26. Convention in Chicago. Secy., T. C. Martin, 29 W. 39th St., New York City.

MASTER BOILER MAKERS' ASSOCIATION.
May 23-26. Annual meeting in Cleveland. Secy., H. D. Vought, 95 Liberty St., New York City.

AMERICAN IRON AND STEEL INSTITUTE.
May 26-27. General meeting in New York City. Secy., J. T. McCleary, 61 Broadway, New York City.

NATIONAL CONFERENCE ON CITY PLANNING.
June 5-7. Conference in Cleveland. Secy., Flavel Shurtleff, 19 Congress St., Boston, Mass.

AMERICAN WATER-WORKS ASSOCIATION.
June 5-9. Convention in New York City. Secy., J. M. Diven, 47 State St., Troy, N. Y.

SOCIETY OF RAILWAY CLUB SECRETARIES.
June 16-17. Annual meeting in Atlantic City. Secy., H. D. Vought, 95 Liberty St., New York City.

TRI-STATE WATER AND LIGHT ASSOCIATION OF THE CAROLINAS AND GEORGIA.
June 21-23. Annual convention at Isle of Pines, S. C. Secy., W. F. Stieglitz, Columbia, S. C.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 27-30. Annual meeting in Pittsburgh. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 27-July 1. Annual meeting in Atlantic City. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Penn.

International Railway General Foremen's Association has decided to hold its 1916 convention in Chicago at the Hotel Sherman, Aug. 29 to Sept. 1. The secretary is William Hall, Winona, Minn.

Pacific Northwest Society of Engineers has just issued a letter to its members reviewing its activities in behalf of the profession and asking continued coöperation. A free distribution of technical proceedings among libraries and other societies has been authorized. A new membership classification and dues schedule have been made: Resident members, $6 per year; nonresident members, $4; associates, $6; juniors, $1.

Atlanta Association of members of the American Association of Civil Engineers has elected the following officers for 1916: President, P. H. Norcross; vice-presidents, V. H. Kreigshaber and W. C. Spiker; secretary and treasurer, Prof. T. P. Branch. Monthly luncheon meetings will be held on the second Tuesday of each month, and visiting members of the American Society are welcome.

Appliances and Materials

Expansion-Joint Filler Strips

Strips of asphalt compound, having a melting point of 260° F., are being made by the Asbestos Protected Metal Co., Pittsburgh, in standardized lengths, widths and thicknesses ready for use in expansion joints of concrete, stone and brick masonry, pavements, sidewalks, etc. It is claimed that the material will withstand the hottest seasons and will not crack under handling in coldest weather.

* * *

Mahogany at Oak Prices

Philippine mahogany is being imported by the Indiana Quartered Oak Co., 52 Vanderbilt Ave., New York City, for building trim and is sold at about the price of quartered oak. This wood is lighter in weight than Mexican or African mahogany and is easier to work; it is claimed that after kiln-drying it stays in place as well as white pine. The lumber is cut in the Philippines in a large modern bandsaw mill cutting 90,000 ft. daily.

* * *

New Nonfreezing Explosive

A new line of explosives, bearing the trade name "Arctic" and claimed to be truly nonfreezing under the most severe winter conditions, is being made by the E. I. du Pont de Nemours Powder Co., Wilmington, Del. While water-resisting, these explosives are not recommended for subaqueous work. "Arctic" powders contain no nitroglycerin and are therefore materially cheaper than straight or extra grades. Their velocity of detonation is reported to be even quicker than that of straight dynamites. They can be used in driving tunnels, shafts or other close work, as the fumes given off on detonation are not obnoxious and will not cause headache. All standard-size cartridges are available; if necessary, they can be packed in bulk in paper bags, which are in turn inclosed in wooden cases. To detonate them properly nothing less in strength than a No. 6 detonator should be used.

There are five different strengths, which on a weight for weight basis are as follows: No. 3, equivalent in strength to a 60% dynamite; No. 4, to a 45%; No. 5, to a 40%; No. 6, to a 30%; No. 7, to a 25%.

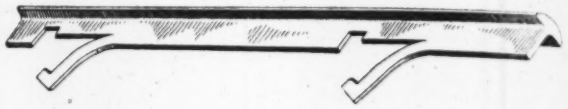
New Clamshell Bucket

An improved design of clamshell excavating bucket has been put out by the Owen Bucket Co., Cleveland. The new bucket (known as "Type L") uses the same block-and-tackle scheme employed in this concern's earlier models. Several parts have been combined in a single steel casting, and longer bearings are used for the working parts, which are lubricated with forced-in grease.

* * *

Curb Guard with Anchor Hook

A curb corner-guard bar with hook anchors is being made by F. W. Stocker, Inc., Hoboken, N. J. The design called the "Ankerbar" is shown in the accompanying sketch. The bar



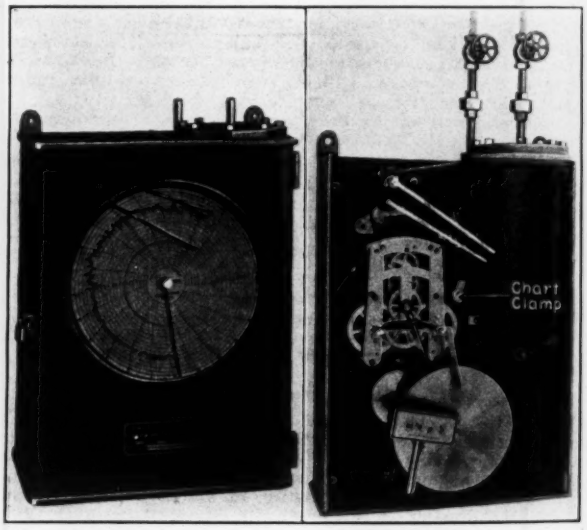
is a rolled section of heavy head and light web, with the anchor hook punched out of the web and bent back.

* * *

New Pipe-Flow Meter

A new recording meter for flow of steam, water, gases and air through pipes has been announced by the Bailey Meter Co., 141 Milk St., Boston. The outfit comprises an orifice plate in the pipe line, with upstream and downstream pipe lines running to a recording differential-pressure gage.

The orifice is the segment of a circle, and the orifice plate is made of $\frac{1}{32}$-in. monel metal, corrugated near its outer edge so as to need no gasket at the pipe connections. At average flows a half-pound pressure drop is secured. For steam and hot-gas work a radiator is connected between the main and each differential-pressure lead line. The greater pressure is led to the inside of a bell floating in mercury and the lower pressure to a sealed housing chamber. The float walls increase in thickness from top to bottom, giving a variable exposed interior cross-sectional area so that the rise and fall are directly proportional to change in pipe flow. This permits a chart with uniform graduations. The pipes and pressure



BAILEY RECORDING FLOW METER

chambers are filled with water when measuring steam and gas flows. In the pressure case is a forked lever carrying the weighted bell on pins. The lever is fixed to a shaft that passes through frictionless packings and carries the pen arm.

An integrator is provided, consisting of a train of counting gears connected to a follower wheel running on a clock-driven disk, the follower and counter unit being moved in and out from the disk center by the float-arm shaft extension. There are numerous details of refinement at different points of the meter to eliminate effects of vibration, prevent spilling or blowing out mercury, etc. The flow meters are also provided, when desired, with standard pen mechanisms for recording pressure and temperature on the flow chart.

Engineering News

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Contents, First Page
Advertising Index, Last Page

An example of Modern Concrete Construction

Naumkeag Steam Cotton Co., Salem, Mass. Mill 4 stories and basement, 722x135. Storehouse 6 stories, 500x110x55. Lockwood, Greene & Co., Engineers and Architects. Turner Construction Co., New York, Contractors. **Havemeyer Bars Used Throughout.**

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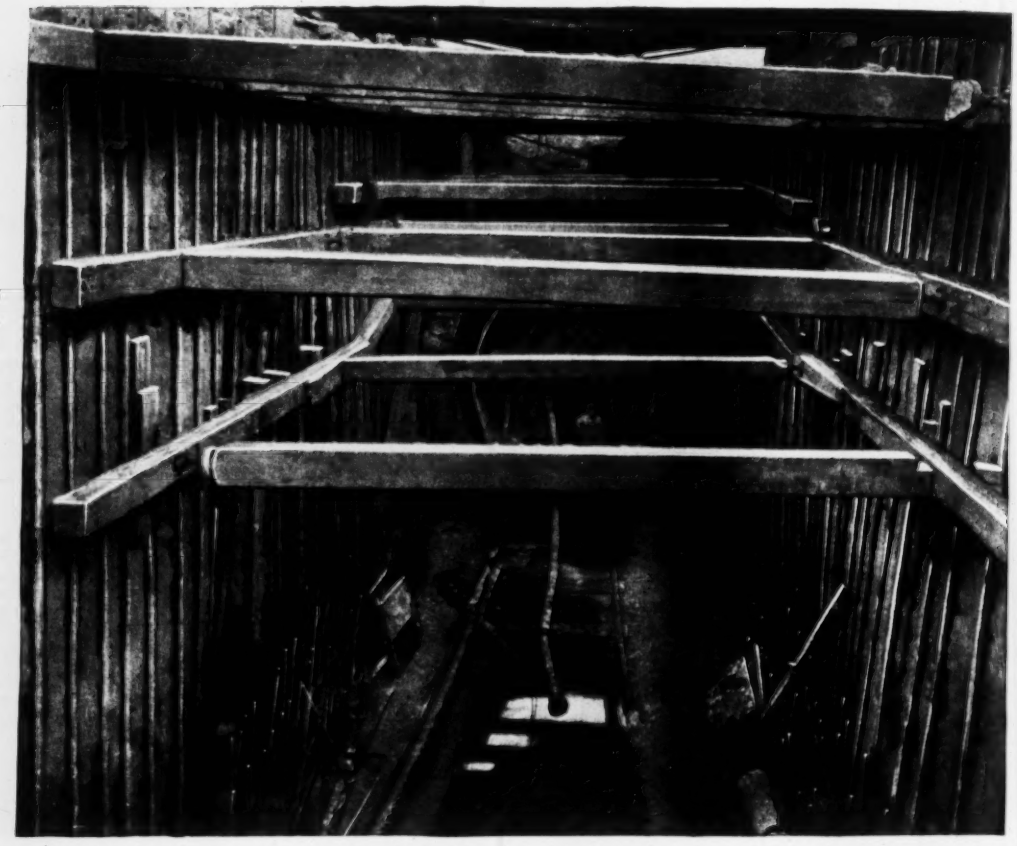
YOUNGSTOWN CHICAGO PHILADELPHIA NEW YORK BOSTON

Agencies and Stocks in Principal Cities



Lackawanna Steel Sheet Piling for Sewer Trench Work

Contractors who appreciate safety, watertightness and economy in driving, pulling and reuse of material are invariably enthusiastic about Lackawanna Steel Sheet Piling for trench work, and now-a-days many of them consider this steel sheeting as standard equipment.

The American Contracting Company of St. Louis has used hundreds of thousands of square feet of our 14-inch Arched-Web Section on the Milltown Creek Joint District Sewer, and this is what they write: Read it carefully for if you have any sewer jobs you should be able to profit from their experience:

"We wish to state that Lackawanna was used in preference to wood or any other type of steel sheet piling, because we found it easier to drive, also that it was much easier to pull than any other type of piling. This piling was all driven full length, except some which we used for bulk-head piling, which was driven in 17½-foot lengths.

"Our construction necessitated watertightness. We are pleased to state that this piling held back the water; in fact in one place where we had a small ditch along the work, we were compelled to burn holes in the piling in order to allow water to seep through.

"We are more than pleased to recommend your piling for this class of construction work."

Lackawanna Steel Sheet Piling is now made in all desirable weights and sections for trench work, and if you are figuring on particularly difficult conditions, the free advice of our Sheet Piling Engineers is yours for the asking.

Managing engineers should also send for and read our book "Lackawanna Steel Sheet Piling."

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For Great Britain and British Colonies in the Eastern Hemisphere, Cargo-Fleet-Iron Co., Ltd., Middlesborough, England. For France, Italy, Spain, French Colonies and Protectorates, Italian Colonies and Spanish Colonies in the Eastern Hemisphere: Cie Des Forges & Aciéries de la Marine et d'Homécourt, Paris, France.

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Engineering News

VOLUME 75 APRIL 27, 1916 NUMBER 17

Reversible Falls Steel-Arch Bridge of 565-Ft. Span

A bridge of unusual interest, third largest among American steel-arch bridges, has been built by the Provincial Government of New Brunswick, Canada, at St. John, crossing Reversible Falls, St. John River. It is a street crossing to take the place of an old suspension bridge close alongside, built in 1852 by William K. Reynolds to the design of Edward Serrell. The increasing density and volume of traffic made the suspension bridge inadequate. The late C. C. Schneider, Philadelphia, was retained as consulting engineer on the question of a new bridge; with his associate, F. C. Kunz, he designed a steel spandrel-braced arch spanning between the sides of the rock gorge.

The structure is of thoroughly modern highway-bridge character as regards detail. This means heavy solid floor and large live-load capacity. The floor is a 6-in. reinforced-concrete slab on I-beam stringers, with a surfacing of 4-in. creosoted wood block. The sidewalks are 4½-in. slabs surfaced with ½-in. cement mortar. Two trolley tracks occupy the middle of the roadway. The bridge also carries an 18-in. cast-iron water main.

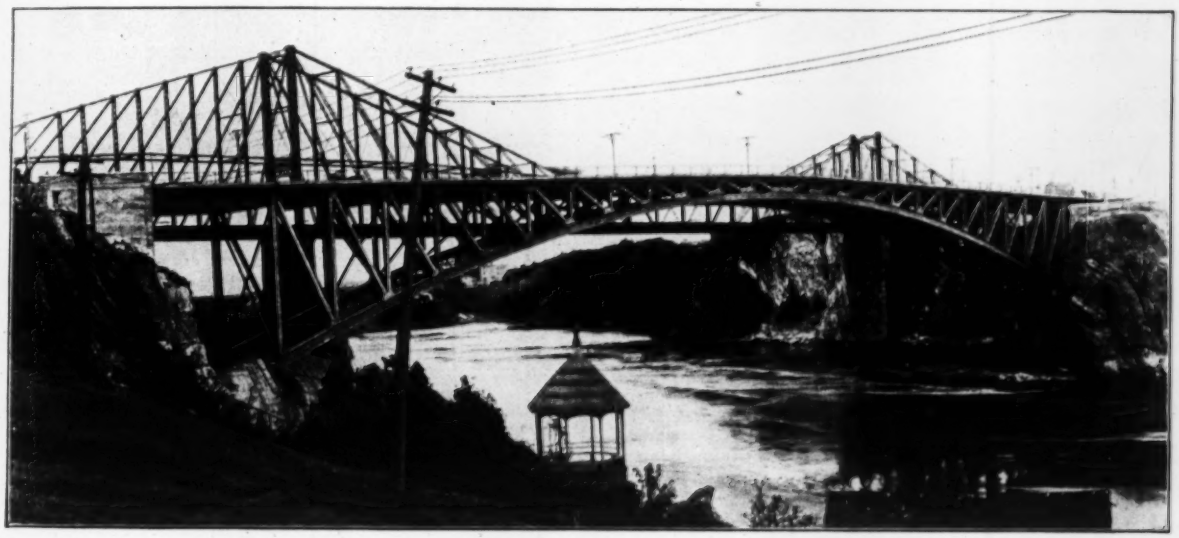


FIG. 1. COMPLETED 565-FT. ST. JOHN ARCH BRIDGE, AFTER REMOVAL OF SUSPENSION BRIDGE

The width and height of the gorge are such as to make the arch of unusually flat proportions. The span is 565 ft. The ratio of rise to span is 1 to 9.2. In due proportion the crown depth is small, 8 ft. 6 in., while the depth at the end post (set 2½ ft. forward of the skewback hinge) is 60 ft. 3 in. The top chord and roadway have an initial grade of 3.215%. The arches are set in vertical planes.

The truss spacing is 41 ft., for a 50-ft. deck, comprising 36-ft. roadway and two 7-ft. sidewalks. The curbs are thus set a short distance in from the inner face of the top chord, and the sidewalk bracket outside the top chord is correspondingly shortened. The panel length is 23 ft. 4 in. uniformly (24 panels).

The dead-loads are summarized by the following tabulation for the completed condition and for erection conditions respectively:

DEAD-LOAD OF ST. JOHN ARCH
(In lb. per lin.ft. of bridge)

After completion:	
Flooring, rails, water pipe, etc.	5,100
Floor system	1,300
Trusses and bracing, average	5,600
Total, average	12,000
Maximum during erection:	
Stringers, floor-beams and rails	700
Trusses and bracing, average	5,600
Total, average	6,300

The average loads given were not used in the calculations, but the actual panel concentrations were taken. A traveler load of 75 tons was taken into account in computing erection stresses.

The live-load was graded for the design of the different structural parts from stringers to main trusses. The specifications for live-load are given in detail in the tabulation shown under Fig. 2 on p. 778.

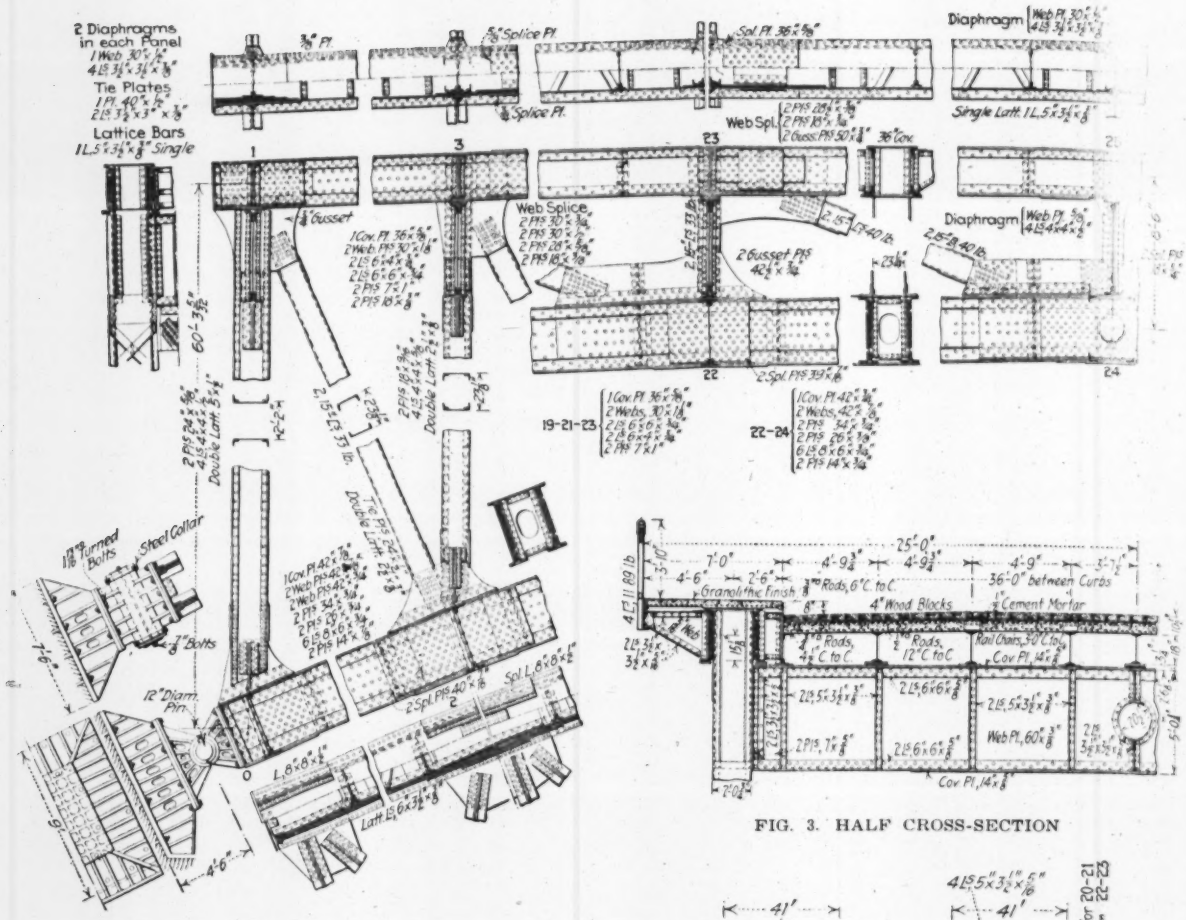


FIG. 2. TYPICAL DETAILS OF ARCH

FIG. 3. HALF CROSS-SECTION

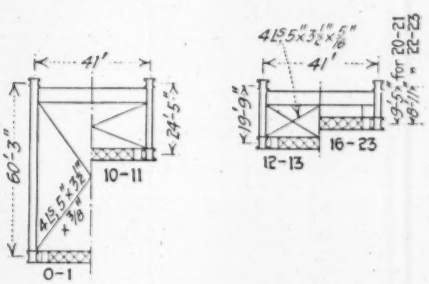


FIG. 5. TYPICAL SECTIONS

Live-Load Specifications

For roadway stringers, one 20-ton road roller.

For trolley stringers and floor-beams, on each track two 8-wheel 40-ton cars end to end, plus 25% impact.

For sidewalks, 100 lb. per sq.ft.

For main trusses, 3,000 lb. per lin.ft. of bridge. This represents 60 lb. per sq.ft. over the whole area between railings, or else 40-ton 40-ft. trolley cars on each track spaced 40 ft. in the clear on both tracks, and 36 lb. per sq.ft. on all other floor surface.

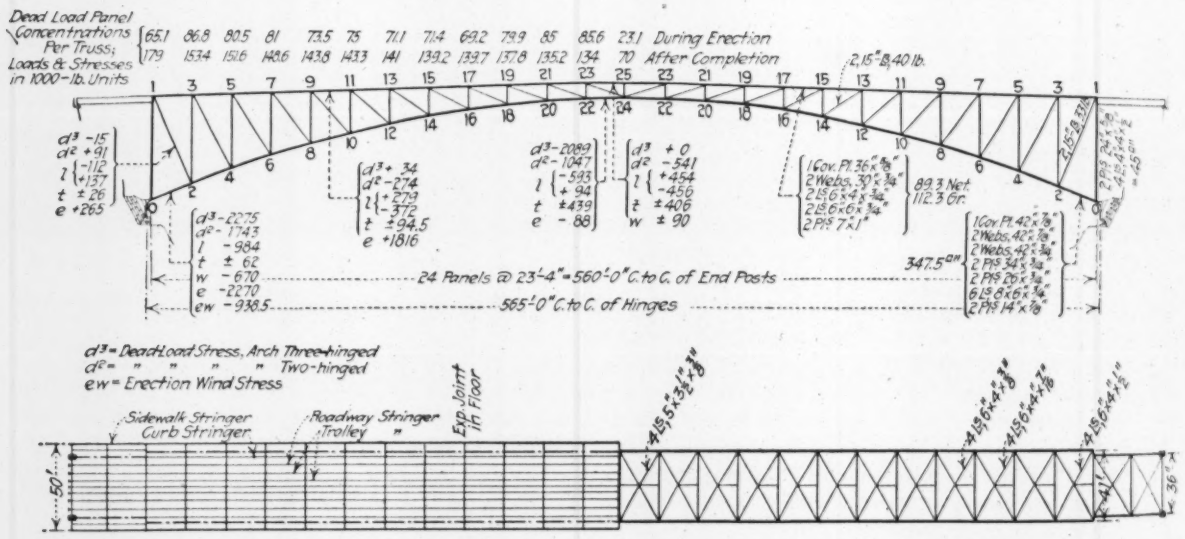

Dead Load Panel Concentrations Per Truss; Loads & Stresses in 1000-lb. Units
65.1 86.8 80.5 81 73.5 75 71.1 71.4 69.2 79.9 85 85.6 23.1 During Erection
179 153.4 151.6 148.6 143.8 143.3 141 139.2 139.7 137.8 135.2 134 70 After Completion
2,15"@40 lb.
24 Panels @ 23'-4" = 560'-0" C. to C. of End Posts
565'-0" C. to C. of Hinges
347.5 tons
89.3 Net
112.3 Gr.
d1 = Dead Load Stress, Arch Three-hinged
d2 = " " " " Two-hinged
ew = Erection Wind Stress
Sidewalk Stringer
Curb Stringer
Roadway Stringer
Trolley "
Exp. Joint in Floor
50'
36'

FIG. 4. OUTLINE SKETCH OF REVERSIBLE FALLS ARCH, WITH LOADS AND TYPICAL STRESSES

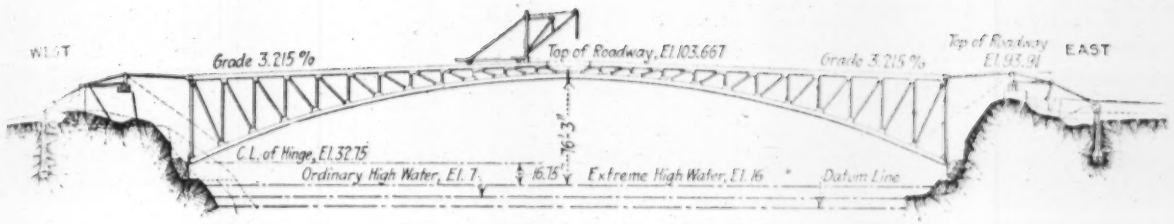


FIG. 6. ERECTION SKETCH OF REVERSIBLE FALLS ARCH

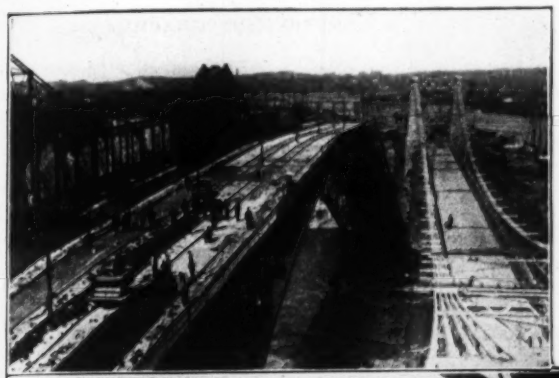
The trusses were erected without falsework, by the usual cantilever method. The arrangement of anchorage and adjusting toggles for the erection and closure is shown by the sketch, Fig. 6.

Closure was made by inserting the top chord member without stress, after lowering the half trusses to contact on a pin at the center bottom-chord joint. The bridge is thus three-hinged for the erection dead-load, but is two-hinged for live-load and temperature.

The main span is flanked by two 46-ft. 8-in. deck plate-girder spans. The total length of steel superstructure is 654 ft. between back walls.

The contract for the work was let early in 1913 by the Chief Commissioner of Public Works, John Morrissy, to the Dominion Bridge Co., Montreal. A. R. Wetmore was Provincial Engineer.

It is of interest to note that the cantilever railway bridge near the arch, which can be seen in the photographs, is, like the suspension bridge, a historic structure. It was erected in 1884, just after Mr. Schneider's Niagara (Michigan Central) cantilever, and thus was among the first three or four of modern cantilevers in America. The Dominion Bridge Co. built it. Its main span is 477 ft. long, containing a 143-ft. suspended span. The suspension bridge, also shown, has since been removed.



FIGS. 7 AND 8. THE THREE BRIDGES AT ST. JOHN, DURING ERECTION OF THE ARCH AND AFTER COMPLETION

Hand Drills in Structural Work

By Charles C. Phelps*

A laborer with chisel or pipe bit and hammer can drill holes of small diameter in concrete at an average rate of about 1 ft. per hr. In brick the rate of cutting is faster. It is apparent that the hand method of cutting is almost prohibitive in cost under many circumstances and would be out of the question if a large number of holes had to be cut in a short time. Various types of rock drills are well adapted to work of this character and, in fact, have been so applied with marked economies in several instances.

A notable job of this nature was the drilling of approximately 9,500 window-bolt holes at the reconstructed Edison Phonograph Works, West Orange, N. J., following the disastrous fire in December, 1914. Each bay required 17 expansion bolts to hold the fireproof steel window frame. It was necessary to drill a hole 3½ in. deep by ¾ in. in diameter in the concrete walls, to accommodate each bolt. These holes necessitated both horizontal and vertical drilling. For the purpose a Jackhamer with a special bit of hexagon steel (Fig. 1) was employed. Two men handled the drill, one holding it and the other guiding the bit (Fig. 2). They averaged 500 holes per day, their work including the frequent moving of scaffold and the changing of air connections. This figure reduces to 15 or 16 ft. of hole drilled per hr. The Jackhamer was used for drilling both horizontal and vertical holes, but many of the up-holes were drilled with a butterfly stope drill (Fig. 3). Both of these drills were also employed for drilling holes preparatory to removing some of the concrete construction.

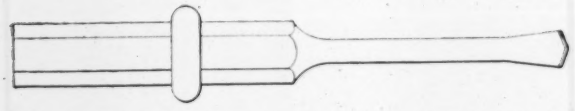


FIG. 1. SPECIAL STEEL USED WITH JACKHAMER FOR DRILLING WINDOW-BOLT HOLES

This is a good illustration of a large number of small anchor-bolt holes drilled economically. An example of a number of large anchor-bolt holes bored at low cost is found in the Quebec Bridge. There were 176 of these holes, 5 ft. deep by 4½ in. in diameter, drilled in granite masonry with a Calyx chilled-shot core-drill. This job was described at length by the writer in *Engineering News* of Feb. 4, 1915.

Miscellaneous Uses for Hand Hammer Drills

Drilling holes in machinery foundations for foundation bolts; in floors for railings; in walls or ceilings for pipe, wire, shafting, conduit brackets or hangers and lighting fixtures; and in walls of buildings for fire-escape brackets are other uses to which pneumatic drills and hammers have been applied with advantage. They are equally valuable for such other applications as cutting openings in floors or walls for windows and doors, shafting, belting, pipes, wires, etc., and for cutting channels in concrete floors or ceilings.

A Jackhamer has seen considerable service along these lines at the Government Printing Office in Washington. The floor construction is of concrete and brick arches,

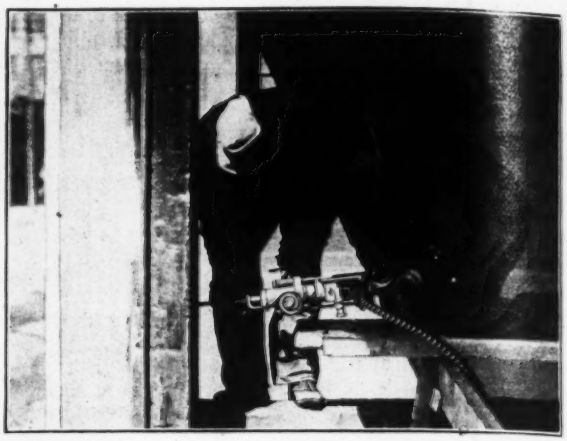


FIG. 2. HAND HAMMER DRILL MAKING WINDOW BOLT HOLES AT THE EDISON PHONOGRAPH WORKS

and the ceilings are constructed of concrete tiles. The space between floor and ceiling is used for piping, electric wires, etc., and it is often necessary to cut holes in floor or ceiling when installing machinery or lights, the Jackhamer being employed for the purpose. The drill takes its air from the regular 50-lb. air lines in the Printing Office. When cutting concrete flooring, one man can drill a hole through the floor (10 to 10½ in. thick) in 2½ min. Ladders or staging are required for ceiling work, and for such work two men handle the drill. The automatically rotated type of drill is especially well adapted for use where footing is insecure or elbow room restricted, as on ladders, falsework or swinging scaffolds.

In another case where hanger holes were drilled in rock it formerly required a whole day for two men with hammer and steel to drill 9 or 10 holes, each 4 to 6 in. in depth, whereas now one man drills the same number of holes in 10 to 15 min. with a hand hammer drill.

Hundreds of elevated-railway column foundations are being removed in New York with the aid of Jackhamers.

FIG. 3. DRILLING UP-HOLES WITH A "BUTTERFLY" STOPE DRILL

*Ingersoll-Rand Co., 11 Broadway, New York City.

These brick footings are located above the new subway in the lower part of the city. They will be replaced by concrete foundations. These footings are in the shape of truncated pyramids 8 or more feet high and about 4 ft. square on top. Fig. 4 shows three of these foundations partly excavated before removal. After the elevated tructure has been supported on falsework, holes are drilled from 12 to 20 in. in depth. The brick is then broken out with sledge-and-wedge.

One of the earlier applications of plug drills for work of this nature was for cutting out concrete and brickwork at the New York end of the Brooklyn Bridge, to make room for a subway terminal. Hammer drills of the non-rotating butterfly type were used, as the more suitable automatically rotated drills had not been developed at that time. The work necessitated cutting through, first, an 18-in. layer of fine cement concrete; next, about 3 ft. of rough gravel concrete; and finally the brick supporting arches or vaulting. The material was cut away in layers or benches—first, the top layer, which, though hard, was fairly uniform and good cutting; next, the rough concrete,

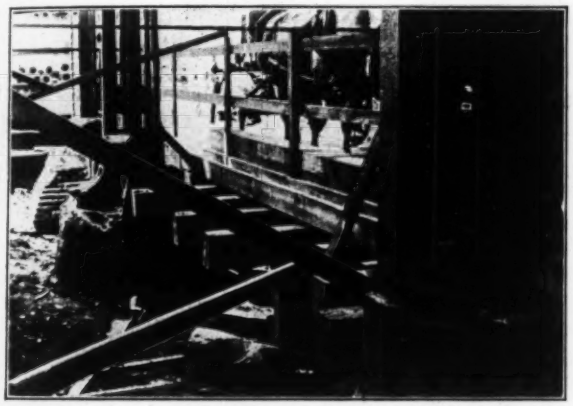


FIG. 4. TYPE OF ELEVATED-RAILWAY COLUMN FOOTINGS REMOVED BY HAND HAMMER DRILLS

which was very difficult to cut; and then the brick, which was comparatively easy cutting. In one instance it was found necessary to cut through a steel tie. This was accomplished with the same drill steel as was used for the concrete, in the surprisingly short time of 12 min. Blasting was prohibited in this confined place—so close to one of the most congested of traffic arteries—and these drills were called upon to pick out all the material piece by piece. For this work a solid hexagon steel with narrow-pointed chisel about ¾ in. across the cutting edge was employed.

A tunnel is being constructed in Seattle to connect the King County courthouse with the City Hall. This work necessitates the removal of large concrete foundations, for which purpose a Jackhamer is employed. This drill was observed to work at as fast a rate as 1 ft. per min.

Large concrete foundations were removed by this method at the Brighton (England) Corporation Electric Works. The concrete was exceptionally hard, and many of the broken blocks weighed as much as 20 tons each. An ordinary chisel bit 20 in. in length was employed for drilling holes all around the foundation, about 9 in. apart and 18 in. deep. The average speed of drilling was 7 holes per hour—that is, about 10 ft. of hole per hour.

When holes are drilled dry in concrete with hand-rotated tools, the natural moisture present in the concrete seems to cause dust from the cuttings to pack and form a mud collar above the bit, making it necessary to withdraw the steel by means of a wrench, which causes considerable delay. This difficulty is not encountered with the automatically rotated type of drill, because its air jet keeps the hole clean and the steel can easily be withdrawn by means of its holder.

Experience with Concrete Roads in Maryland

The State Highway Department of Maryland, under the direction of Henry G. Shirley, Chief Engineer, has built a larger mileage of concrete roads than the highway department of any other state except California and New York. A recently issued report says:

The cost of maintaining macadam, gravel, sand-clay and bituminous roads is such that Chairman Weller and Chief Engineer Shirley soon after their induction into office in 1912 made a careful study and investigation of a more substantial type of construction, especially of concrete. Several experimental sections of concrete roads were laid in 1912. In 1913 six additional miles were constructed, 116 in 1914 and 65 in 1915, making a total to date of about 190 miles.

These roads have been subjected to heavy traffic, and the cost of maintaining them has been almost negligible. When the building of this type of road was started, it was new to most of our contractors and bids on the concrete varied from $1.30 to $1.50 per sq.yd. However, with more experience in this class of work and better equipment facilities, contractors have become more familiar with the handling of concrete and the price has dropped from a maximum of, say, $1.50 in 1912 to a minimum of 90c. in 1915.

The cost of maintaining these concrete roads has been so small that the commission feels that the building of so many miles of them has been of great benefit to the state. With reasonable attention, these roads should last many years. In fact, if a bituminous covering is applied after the concrete surface has worn a certain amount, they should last indefinitely. Most of the concrete roads built during the last two years have not been covered, as it was found unnecessary to cover them for a period of four or five years under normal traffic and that after this period a bituminous coating adheres very much better than if applied when the road is first completed. This also saves the cost of this surfacing for that period. In many places on the Eastern Shore, concrete has been laid at a lower cost than macadam.

The method of repairing cracks in the concrete is the usual one of applying melted tar and sand. This work is now so well standardized and the repairs made in this way are so satisfactory that cracks in concrete roads are no longer considered of any especial importance. Reinforcement has not been used on the Maryland concrete roads; and even though its use would diminish or prevent cracking, Mr. Shirley finds that such cracks are of so little importance that reinforcement would not be justified.

While various types of transverse joints have been tried on the Maryland concrete roads, Mr. Shirley now favors the entire omission of joints except at the end of a day's work. He finds it little, if any, more trouble to repair a transverse crack which forms across a road than to maintain a transverse joint. Where transverse joints are placed it is difficult to make the joint so smooth that it will not be felt when a car passes over it. Trouble has also been experienced where transverse joints are used with one slab rising above the adjacent one.

Although the commission believes in and favors the concrete road, other types of road are constructed, as account is taken of local prejudice in favor of one type or another and in some parts of the state it is difficult to obtain suitable sand for concrete except by a long haul.

Water-Supply of Panama Canal Under Operating Conditions

By R. Z. Kirkpatrick*

The year from September, 1914, to September, 1915, had the greatest water consumption for lock operation since the canal was opened. Except for a heavy rainfall and runoff in February and April, 1915, the inflow to Gatun Lake was about average during the year. The diagrams in Fig. 1 show the principal losses from Gatun Lake. Pumping for dredges and town water-supplies, leakages and seepage losses are too small to show on the scale. In December, 1915, pumping and leakages amounted to 29 and 15 cu.ft. per sec. respectively. Seepage is almost nothing. Normal leakages have been determined as follows:

Location	Area of Openings Closed by Gates, Sq.Ft.	Leakages, Cu.Ft. per Sec.
Gatun locks	11,990	5.93
Gatun spillway	11,410	3.64
Pedro Miguel lock	11,990	4.99
Miraflores locks	10,250	5.30
Miraflores spillway	5,520	0.86

These are very satisfactory values. Additional leakage occurs, however, when caissons are used instead of valves or gates. The original water-supply estimates allowed 275 cu.ft. per. sec. for leakage from Gatun Lake structures.

The water loss per lockage decreased later in the period shown in the charts, due to more crossfilling from one twin lock to another, use of 650-ft. lock lengths or passing more than one vessel in a chamber at a time. Use of water for lockage will increase of course with the growth of traffic. The locks are designed to permit 48 lockages a day, or 1,440 a month, but so far the greatest number of lockages a month was 182, at Pedro Miguel in July, 1915. Probably the maximum lockage requirements will not be reached for many years. The jump in the use of water for power in January, 1915, marks the beginning of all Isthmian power generation at the hydro-electric station. Before January, 1915, but one of the three turbines had been running. The original water-supply estimate of 275 cu.ft. per sec. for the hydro-electric plant did not anticipate the construction of auxiliary plants, such as coaling plants, dry docks, shops and relay pumps. About 1,000 cu.ft. per sec. is now used for generating power, and this figure is not the maximum to be expected.

Gatun Water Supply Ample

Experience so far indicates what was expected; namely, there is ample water-supply from the natural inflow to Gatun Lake, except in the dry season, when storage water must be used in part. With Gatun Lake at +87, from 5 to 7 ft. of storage, or 22.75 to 31.90 billion cubic feet is available before the depth is reduced enough to hinder shipping. The 1915 dry-season hydrology of Gatun Lake is shown in Table 1.

The total yield for 1914 was 102% of the capacity of Gatun Lake at +85; this is but a little more than the average yield. Careful hydrologies of Gatun and Miraflores Lakes and Chagres River watersheds are kept. Rainfall stations are located on various parts of Gatun Lake and along the line of the canal and extend up the Chagres as far as the Rio Culebra and Rio Indio, twenty-five miles above Gamboa. The estimated rainfall over Gatun Lake drainage area and watershed is calculated by averaging the monthly precipitation of adjacent stations and weighting the intervening section average with the section area. The general average of the weighted averages is the rainfall used in the hydrologies.

United States Standard Weather Bureau and tipping-bucket rainfall equipment is used, also the Friez automatic water-stage register. The latter is essentially a metal

*Assistant Chief Hydrographer, the Panama Canal, Balboa Heights, Canal Zone.

TABLE 1. RECORD OF GATUN LAKE HYDROLOGY, JANUARY TO APRIL INCLUSIVE, 1915

Gatun Lake:	
Dry-season mean elevation	86.81
Maximum elevation (Feb. 10)	87.20
Minimum elevation (Apr. 24)	86.32

	Quantities	
	Million Cu.Ft.	Cu.Ft. per Sec.
Gatun Spillway:		
Waste	23,263.5	2,243.8
Leakage	37.7	3.6
Gatun Locks:		
Lockage and tests (492 lockages)	1,980.2	191.0
Leakage	61.5	5.9
Gatun hydro-electric plant	8,311.8	801.7
Pedro Miguel Locks:		
Lockage and tests (491 lockages)*	1,744.4	168.2
Leakage*	75.2	7.3
Pumping at Cucaracha slide*	97.0	9.4
Brazos Brook reservoir	118.0	11.4
Pumping at Gamboa	64.2	6.2
(a) Total outflow	35,753.5	3,448.5
(b) Storage (+ increase, — decrease)	—1,257.0	121.2
(c) Net yield (a + b)	34,496.5	3,327.3
(d) Evaporation on lake (24.31 in.)	9,427.5	909.3
(e) Total yield (c + d)	43,924.0	4,236.6
(f) Rainfall on lake (21.91 in.)	8,492.0	819.1
(g) Yield from land area (e — f)	35,432.0	3,417.5

	Mean Area, Sq.Mi.	Rainfall, In.	Runoff, In.	Percentage Runoff
Lake surface	166.9	21.9	21.9	100.0
Land area	1,153.1	19.2	13.2	68.0
Total watershed	1,320.0	19.6	14.3	73.0

* Into Miraflores Lake.

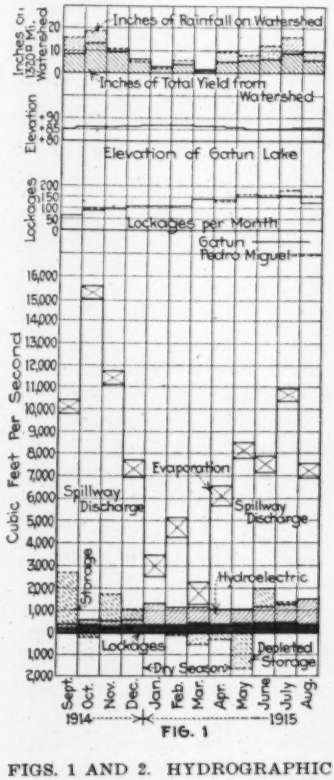


FIG. 1

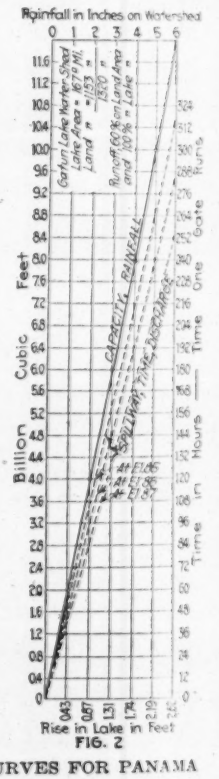


FIG. 2

FIGS. 1 AND 2. HYDROGRAPHIC CURVES FOR PANAMA CANAL

Fig. 1—Diagrams showing rainfall and runoff from Gatun Lake drainage basin; elevation of lake surface, number of lockages per month and outflow and losses from the lake. Fig. 2—Diagram showing effect of rainfall and spillway outflow on Gatun Lake level

float suspended from a tape and counterweighted over a sprocket wheel; a pen plots a hydrograph on the sheet on a drum that is geared to a clock; the drum has a common axle with the wheel. The more important water-stage register stations have daily sheets; the others are changed weekly. At Gatun and Pedro Miguel locks, Gatun spillway and Gamboa, concrete towers, lighthouse type, Fig. 3, were built for the water-stage instruments. These towers are equipped with anemometers recording wind directions and velocities. This arrangement is useful in studies of water-stage heights, currents and wind, giving permanent automatic records. Other water-stage instruments on sheltered wooden platforms are located up the Chagres River and along the lake for studies of freshet runoff. Juan Mina Lake station has recorded as high as a 1.5-ft. head above Gamboa; and Gamboa, 0.2 to 0.3 ft. above Gatun, during a Chagres River freshet.

Discharges at Gatun spillway channel and at Alhajuela are occasionally measured with single and penta recorder Price current meters; gagings are made from a gaging car, suspended from a cable. Lake or channel-current velocity gagings are made from boats at anchor. A Haskell-Richie current velocity-direction meter has given good results in charting channel currents.

Evaporation records over Lake Gatun are obtained from a copper pan, 4 ft. in diameter and 10 in. deep, floating in an open section of the lake. An anemometer for recording wind movement, a thermometer for water temperature and a standard rain gage complete the equipment. The pan is protected from waves by a wooden frame, properly buoyed. The station is so located to give lake conditions. The water in the pan is kept about 4 in. from the top, and the daily readings are corrected for precipitation. The average Gatun Lake evaporation is about 61 in. a year and is much heavier in the dry-season months and during daylight hours.

Gatun Lake Control

The control of Gatun Lake during freshets is handled so quietly that dredgemen and shipping in the lake usually do not know a freshet is in progress. A variation of 0.15 ft. in the lake elevation is commonly the maximum. A general rainfall over the whole watershed is exceptional, the common type being a sudden downpour in one section. The Chagres River section produces one-third of the outflow in a general rain, but is subject to more frequent local freshets. Flood-warning stations are located at Vigia and Alhajuela; a rising river warns the local observers by ringing an alarm bell. The flood-control hydrographer at Balboa Heights is in touch with the river stages through telephone reports at least each half-hour during freshets. From his rating curve it is known how much water is coming several hours before it reaches the lake. In like manner the flood-control hydrographer gets rainfall and lake-stage reports from most of the lake stations; from these data he gives telephoned orders for the opening and closing of the spillway gates at Gatun. His position might be called "water dispatcher." During the wet season it is exceptional if at least half an inch of rainfall does not occur at some place during each 24 hr.; prompt reports, day and night, are therefore necessary to operate the spillway intelligently.

Curves showing the rise to be expected from a given rainfall over a given watershed area, the probable yield resulting and the time taken by one spillway gate to waste

FIG. 3. WATER-STAGE RECORDING STATION AT GAMBOA

this yield are helpful in properly handling the spillway operation. For example, referring to the curve, Fig. 2, a general 5-in. rainfall on the whole watershed will yield 9.976 million cubic feet, produce a 2.2-ft. rise, and it will take one gate 317, 286 and 255 hr. at lake elevations +85, +86 and +87, respectively, to waste this water. It is necessary to let the water out about as fast as it reaches the lake, to prevent a rise of less than 0.15 ft. So far this has been done by the simultaneous operation of not more than six spillway gates with a maximum discharge of 71,340 cu.ft. per sec.

Calibrating Spillway Discharge

The Gatun spillway gates have been calibrated for discharge between El. 84 to 87. This was done by measuring the discharge by 44 current-meter gagings in the lower spillway channel. At lake El. +87 a gate opening is 18.11 ft. in depth by 45 ft. in length, which equals 815 sq.ft. These openings are very deep, broad-crested weirs. The photograph, Fig. 4, shows seven such openings discharging during a test. Average values of C in the well-known Francis formula $C = \frac{Q}{LH\sqrt{2gH}}$ were calculated from the measured discharges, and a rating curve and table were prepared. C has a value of 3.77 and 3.60 at El. 87 and 85 respectively. In designing an opening sufficient to waste 154,000 cu.ft. per sec. the designing engineers used a flat value of $C = 3$. Actually, the 14 gates will discharge $13{,}075 \times 14 = 183{,}050$ cu.ft. per sec. at +87, and with a possible 50,000 cu.ft. per sec. more wasted through the lock culverts at Gatun and Pedro Miguel locks, ample control of floods of record volume is assured.

Data on maximum current velocities due to Chagres River freshets have been obtained by current-meter measurements taken at 1-ft. depths at Gamboa bridge and are shown in Table 2.

The currents are at right angles to the Panama Canal channel, the bridge being just north of the east bank of the canal. The backwater of the arm of the lake extends about 8 mi. above Gamboa bridge. None of the freshets shown are as big as have occurred before the lake was formed, but the results are reassuring. Careful studies of incoming sediment above Gamboa bridge are impossible now. Gravel and sand for concrete and ballast on the Canal Zone are dredged from the old beds above Gamboa; this is a great advantage from the standpoint of economical construction, besides subtracting from the filling-up tendency. The 1-ft. depth freshet velocities are gratifying as to possible shoaling in the canal channel. Only very fine silt shows at the municipal-engineering intake south Gatun Lake stations read 0.02 to 0.15 ft. [illegible] in the afternoon than early in the morning. The opposite effect is noticed at Gatun, but not so marked, the lake falling from 0.01 to 0.05 ft. Considerable wave action is noticed along the shore line near the Agua Clara lighthouses, owing to the long sweep of the wind over the lake.

Surges are set up in Gaillard Cut when water is admitted to Pedro Miguel lock. Repeated valve operations are sometimes accidentally so timed as to cause harmonic increase to these surges. With various phases of movements of ships and dredges, lock-valve operations, opening and closing of the Paraiso pontoon bridge and wind direction, the surges become hopeless for study. That they do follow a given law is sure. The Pedro Miguel

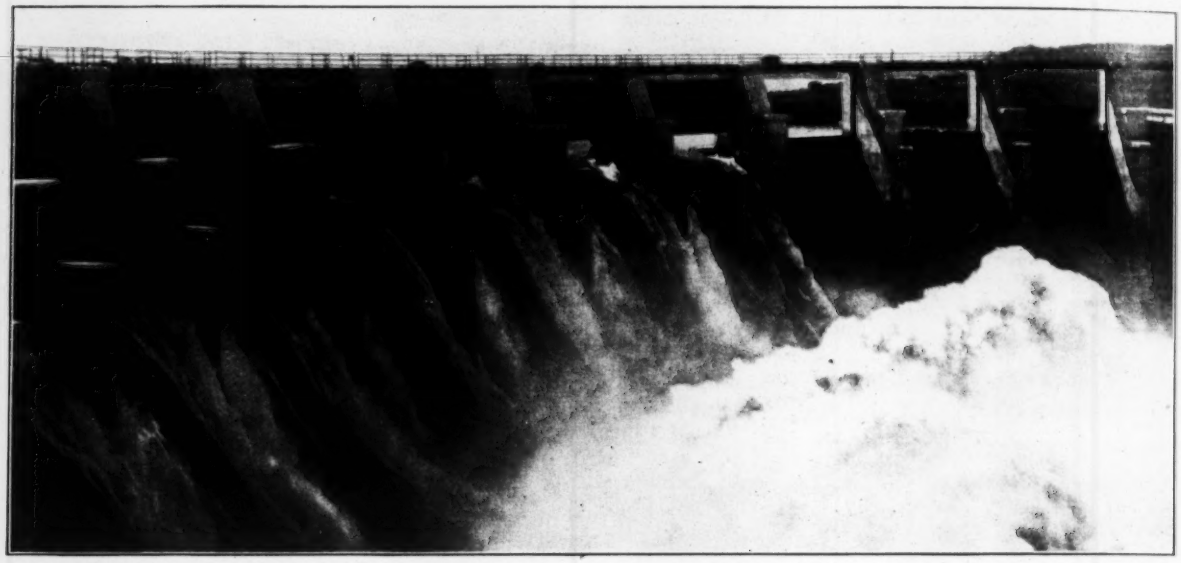


FIG. 4. DISCHARGE OVER GATUN SPILLWAY DAM WITH SEVEN GATES OPEN

and pumping plant, which leads to the Miraflores Filtration Plant, and is located just above Gamboa bridge.

Current velocities in Gatun Lake due to simultaneous discharge of four to five spillway gates show greater velocity at Bohio narrows, 9 mi. from the spillway, than in the canal channel, only ½ mi. from the spillway; 2,000

TABLE 2. CURRENT VELOCITIES IN GATUN LAKE

Date	Discharge in Cu.Ft. per Sec. Alhajuela	Gatun Spillway	Gatun Lake Elevation	Current Velocity in Ft. per Sec.	Mi. per Hr.	Knots
May 26, 1914	15,900	10,390	84.92	0.95	0.65	0.56
June 30, 1914	20,050	41,380	84.88	1.54	1.05	0.91
July 28, 1914	25,300	30,972	84.86	1.83	1.24	1.08
Aug. 22, 1914	21,600	20,905	84.97	1.61	1.10	0.95
Sept. 7, 1914	28,665	52,265	84.97	2.11	1.43	1.24
Oct. 7, 1914	31,200	70,680	86.10	2.11	1.43	1.24
Apr. 3, 1915	27,085	63,895	86.67	1.74	1.19	1.03

and 1,475 ft. per hr. at 1-ft. and 20-ft. depths at Bohio and 1,080 ft. and 730 ft. per hr. at 1- and 15-ft depths at about ½ mi. from the spillway are the records. Spillway discharge from five gates also caused a measured drift toward the spillway of 3,565 ft. to 1,510 ft. per hr. at 5- to 20-ft. depths along the east side of Gatun locks upper approach wall. Wind was blowing toward the spillway from 8 to 25 mi. per hr., the higher wind velocities occurring with the higher current velocities.

During dry-season months the trade winds blow steadily from a northerly direction and hardest during the day. The effect is that gage rods at Gamboa and other lockage surges are recorded at the Juan Mina and San Pablo water-stage instruments. During the lockage of the steamship "American Transport," northbound, Nov. 7, 1914, all conditions for a natural surge were typical. The time interval and amplitude of surge from crest to trough were observed as shown in Table 3.

TABLE 3. TRAVEL OF SURGE IN GAILLARD CUT

	At Pedro Miguel Lock		At Gamboa		At Juan Mina	
	Time	Lake Elevation	Time	Lake Elevation	Time	Lake Elevation
Effect of opening valves started	11:40 a.m.	85.94	12:01 p.m.	85.95	12:25 p.m.	85.94
Trough of wave	11:45 a.m.	85.23	12:05 p.m.	85.82	12:30 p.m.	85.90
Crest of return wave	12:30 p.m.	86.60	12:45 p.m.	85.98	1:15 p.m.	86.00

Pedro Miguel lock to Gamboa is 9 mi.; to Juan Mina, 15 mi.

Current velocities, due to mixing of fresh and salt water, occur at the sea-level ends of Gatun and Miraflores locks. At 1-ft. and 2-ft. depths currents of 6 and 4.5 ft. per sec. at high tide of +8 and low tide of —7 respectively at the lower Miraflores locks miter gates have been found. It has been learned that after opening the gates there are (a) an upper fresh-water volume moving out to sea, (b) a neutral volume with no motion between the depths of 15 and 25 ft. from the surface of the water and (c) a lower salt-water volume moving into the sea-level lock chamber. The net effect of these currents is to hamper boats in picking up speed for leaving the locks.

Constant-Level Orifice Box Feeding Chemicals

By Weston Gavett*

One of the most important features of a water-purification plant where chemicals are employed is the apparatus for applying the chemicals to the water, but good automatic apparatus has not always been available because of its expense. The following notes describe a constant-level orifice feed box designed by the writer for a place where an inexpensive installation was required. The experimental box combines the features of two old types and performs so well that, if the idea should prove not to be new, it is unfortunate that the arrangement has not been more used.

The need of good semiautomatic feeding apparatus for small plants is real, and here the importance of an accurate application of chemicals is too often under-estimated. The nontechnical attendant has the impression that all is well if any coagulant at all is going into the water, while the tendency of the chemist in charge of a plant is sometimes to place too much importance on the laboratory control and overlook the mechanical end of the plant, where minor improvements may be rewarded by savings in operating cost and increases in efficiency.

With waters of excess alkalinity, it may be possible to use a considerable excess of alum and obtain good efficiencies from the purification standpoint, but economy suffers. These conditions are especially apt to breed carelessness in exact feeding. When the alkalinity is deficient and lime or soda ash is required, when iron sulphate and lime are used for coagulants or when using hypochlorite of lime, the great importance of adding the solutions exactly as desired needs no enlarging. Complaints due to taste from an excess of "bleach" and occasional decreases in the efficiency of sterilization are more apt to be caused by the poor chemical appliances than by an error of judgment of the operator in determining the amount that was supposed to have been used.

It is customary in most plants to check the amount of solution run by readings of the level of solution in the tank, using a float and scale, gage-glasses or recording gage. This plan gives an accurate and necessary check on the amount that has been run, but does not show the actual rate at any time. By throttling a valve on the feed line very good results are often obtained. A good filter attendant by constant practice may obtain surprising proficiency in estimating the flow. In fact, this method may give better results than with some orifice boxes. Such dependence on the human element, however, is not desirable.

The usefulness of an orifice box depends largely on two factors: (1) The method of maintaining a constant head; (2) the method of varying the size of the orifice. The general forms of boxes are the weir and the float-valve type. In the weir box the solution is pumped to the box, which is above the tank, and the excess is allowed to overflow a weir to the tank. The head obtained is practically constant, but the pumps and their upkeep are expensive. The float-valve type seems less desirable. A certain amount of variation of level is essential to the operation of a float valve, and in practice the actual variation greatly exceeds the theoretical amount, owing to clogging of the valve, lost motion, friction, etc. With a float valve a deep box is desirable to reduce the error from the variation of head.

The accompanying figures show a box devised by the writer to combine the advantages of the weir and float-valve types without their disadvantages. The operation of the box is shown diagrammatically in Fig. 1. The solution from the tank enters the main compartment, the largest part passes through the large orifice, and the excess overflows the weir into the small compartment. This excess is the amount that flows through the small orifice and is not wasted, but goes to the water with the solution from the main orifice.

The main compartment has a constant head at all times; so if a good orifice is used, the greater part of the flow is accurately applied. The variation in level caused by the float valve affects only the little compartment and the very small flow from the little orifice.

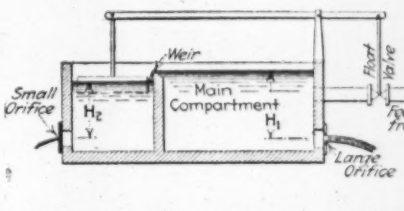


FIG. 1. DIAGRAM OF COMBINATION WEIR AND FLOAT-VALVE ORIFICE BOX

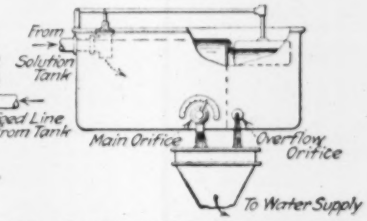


FIG. 2. ARRANGEMENT OF GENERAL SERVICE CONSTANT-LEVEL FEED BOX

In the experimental installation the available head was very limited, and only 7 in. could be used for H_2. The following compares its accuracy with the common float-valve type: Assume 90% of the flow from the big orifice and 10% from the little. Call the variation in H_2, due to the float valve, 1 in. The percentage error in the flow from the small orifice due to this variation is 7%. Thus 90% of the flow has an error of zero, and 10% has an error of 7%, or the mean error for the combined flow is 0.7%.

If still more accurate results are desired and the use of a pump is not objectionable, the smaller flow can be pumped back to the tank. This would require a much smaller pump than is needed for the common type of weir box. Fig. 2 shows a box of this combined type designed for general use. The points to be considered in design are: The little orifice should be as small as possible, but large enough to prevent serious clogging; the small compartment should be just large enough to contain the float and yet allow a free weir discharge; the large orifice may be of any good type. The writer prefers the use of separate orifices of constant size to the adjustable variety. With six orifices in the main compartment (0.5, 1, 2, 2, 5 and 10—the figures represent the proportions of the flows of the different orifices) and one in the float compartment (0.5) any flow from 0.5 to 21 could be obtained, increasing by increments of 0.5, or 42 different flows. In the experimental installation the solution tank was divided into 100 divisions, and the units of flow used for the orifices were divisions per hour. This method made a simple and convenient system for the attendants.

With accurately calibrated orifices of constant size clogging is apparent. With constant head and free orifice the flow is exact and there is no dependence on moving parts.

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Filing Correspondence in a Municipal Department

By Robert J. Fee*

In a municipal department there are changes in executive management with each city administration. This procedure is defended on the ground that the elective official must have in the different branches of the service lieutenants who will sympathetically carry out his political policies. Established office routine, however, that has been standardized and found efficient is seldom disturbed by the new appointee except, perhaps, to be strengthened. No matter what the administrative policy may be, a routine channel of checks is essential; and a tried methodical system already installed provides this. The scope of the present article is limited to the filing and indexing of correspondence.

The filing system is an essential detail of organization, and it must always operate satisfactorily. For instance, it is often imperative, as during hearings, to produce a document immediately; time cannot be spared for a prolonged search. It would seem a simple matter to file a letter under the subject of its contents, but upon consideration certain difficulties immediately appear. Suppose a letter, for example, treats of sureties, or some other question, directly concerned with a dozen contracts. The contracts become primarily concerned and then are of the most importance, since the matter may affect the payments thereunder. To file separate copies under the various subjects discussed or, in the case mentioned, under a dozen different contracts, is wasteful duplication, besides congesting the files, while to limit a communication to a single subject is poor economy.

Transfer from a Subject File to a Subject Index

The difficulty experienced in filing papers supporting the records of the proceedings of the Board of Water-Supply—a municipal department created to build the Catskill water-supply of the City of New York—was solved by Edward S. Brownson, Jr., assistant secretary, about a year after construction was inaugurated. The filing of documents according to subject had been found to be inadequate. The method adopted was to file by accession number, which was indexed on cards according to the previously established classification. The old subject list was thus continued, but was confined to the index, the papers themselves being distributed in the files under their various file numbers. An original paper can be filed in only one place, but it is an easy matter to point out this location by one or more directory entries in a card index.

No peculiarities of any elaborate and complicated scheme had to be worked out, and at once the progressive numbering system proved its superiority for an office handling a large enterprise. The method embodies economies of time and space by fixing a definite location for contents and by eliminating dead space, as growth occurs only at the end last added. No readjustment is necessary owing to expansion of any one subject, and the cabinets seldom used may be removed to less valuable space.

The principle of the serial-number plan is to stamp each new communication with a new accession number and catalog its contents in the index. When the answer comes along, it may, if strictly germane, be given the same number; but if the subsequent correspondence is prolonged and numerous reports are received, covering ramifications, each distinct step in the matter is given a new number. Each transaction thus becomes separate and is not confused with that which precedes or follows.

Use of the machine stamp in assigning a new number also saves time taken to look up previous records of the subject treated in the letter at hand and eliminates the possibility of a transposition or other error of transcription. Should, however, a paper be given a wrong number, it only means that the entries under two subjects will bear the same file number and that the papers of each will be filed together instead of separately—not a great sin when the papers are few.

Cards bearing subject headings are arranged in a single alphabet, on the plan of a dictionary. Entries are made in compact form, and where necessary, general and particular connecting references are given to topics more or less related. The making of interlacing references is elastic requiring judgment, according to the necessities of the case, to save repetition and needless extension and to weave a fabric that will enable the inquirer to trace the allied branches of a subject of which he has only a clue. Everything on a given topic is set forth in a tabular synopsis with distinctions between items, aided by different file numbers to lessen the labor of the investigator, should he desire to examine the correspondence on some particular phase of the group. The file number, then, points exactly to the few specific papers bearing it, in contradistinction to the subject number of other systems which refer to a great mass of matters bearing the same general subject name, but which may or may not be related to each other. With an index these matters appear under one heading on the cards, but are there analyzed and the file number used to narrow the limits.

A Matter Not Located Is Nonexistent or Lost

A glance through the cards on a given subject is sufficient to indicate whether a paper exists or a certain action has been taken. This avoids laborious search through files without result and the further mistrust that the data desired are not buried away in a report filed under some other subject. When a card catalog is intelligently maintained in connection with the files, information of this sort is brought out clearly. If a matter does not appear in the index, there is a fair amount of certainty that the matter does not exist; but in searching a subject file not checked by a supplementary index, all the searcher can say is that the matter cannot be located. Following is a sample of the entries under the subject indicated:

CONTRACT 423

	Date of Meeting		Page
See also Rondout Watershed.			
Printing authorized (57295)	July	1	536
Galley sent to Corporation Counsel (57364)	Sept.	9	755
Galley approved as to form (57364)	Sept.	16	777
Pamphlets sent to Corporation Counsel (57631)	Sept.	23	798
See Real Estate, Rondout, Section 7, Parcel 221 (57718).			
Pamphlets approved as to form (57631)	Oct.	14	838
Advertisement ordered (57821)	Oct.	21	890
Advertisements placed (57821). Copies filed with Comptroller (57903)	Oct.	28	913
Bids opened (60014). Referred to Secretary	Nov.	11	957
Report on bids (60014) referred to Committee of Whole	Nov.	18	975
Awarded to A. B. Smith Co. (60150)	Dec.	2	1011
Notice of award given (60150). Deposits released (60217)	Dec.	9	1036
Delivered, filed, notice to commence work given and engineer notified (60383)	Dec.	16	1054
Registered and Comptroller's certificate indorsed (60469)	Dec.	23	1079
See Police (60471)	Dec.	23	1083
Pauper bond filed with Newtown (60584)	Dec.	30	1092

*Indexer of Board of Water-Supply Records, New York City.

The first cross-reference, "See also Rondout Watershed," probably refers to the preliminary stages of the work before it had advanced sufficiently to be embraced in a contract and given the designation 423. Under the heading "Rondout Watershed" there is a reference to the authorization of the contract. The next cross-reference, "See Real Estate, Rondout, Section 7, Parcel 221 (57118)," evidently refers to some matter indirectly concerned with the contract, probably the acquisition of property. A file number is given in this case, making it more restrictive and limiting the searcher's examination to the entries under the parcel mentioned that bear this file number, disregarding all others as not pertaining to the matter at hand. In this respect the reference is more definite than a general reference. The next, however, "See Police (60171) Dec. 23—1083," is still more specific, as the whole matter is included in the minutes of a single meeting and described on page 1083 under the heading indicated.

It probably suggests itself to the reader that all cross-references should be similar to this last illustration. The answer is that it is simply a question of economy and how much detail is desired. As a rule, blanket references are never made to the general mass of matters under a subject where the file number, and if possible the date of meeting with its folio, can be given in addition to the subject. Where the information is strung over an extended period, the meeting date is left out; and if the file numbers are many, so as to make the reference almost general in character, they too may be omitted.

Under the names of the various bidders we also make a brief notation, as "Bidder for Contract 423 (60014) Nov. 11—957," and under the contractor's name the additional entry, "Awarded Contract 423 (60150) Dec. 2—1011." Cross-references would also appear under the name of any complainant or person in whose favor a payment warrant is ordered. The hanging indention is used to save repetition, and the cataloger's method of underscoring to indicate further indexing may be adopted to advantage. It will be noticed that the entries under the subject are arranged in chronological sequence. This is necessary owing to the difficulty of selecting an alphabetic keyword, although an attempt is made to choose a characteristic or significant catchword to begin the modifying-phrase entry. One of the tests of efficiency is preparedness, and liberal cross-references secure this and add to the utility value of the index. If there were no other reason this would be sufficient to justify the use of cards.

Dewey System Not Practical; Simpler Classification Better

In the case of the Board of Water-Supply proceedings an index to the minutes is an index to the files, the only addition required for the former being the date of meeting and page citation where a digest of the matter can be found. In many cases the index alone supplies all the information desired on a given subject in condensed form, so no consultation of files or minutes is necessary, since the entries under each heading form a continuous though skeletonized narrative. The index is printed annually and distributed to those receiving the proceedings.

The Government Commission on Economy and Efficiency, which approves of the Dewey decimal system of classification, says of the numerical system: "It merely enables the file clerk to get hold of particular letters, but it does not gather papers on the different branches of a subject. If all papers bearing upon a matter are desired, they must be searched for under various heads in the card index." In reply to this we would say that ordinarily it is a direct advantage to find a particular paper so easily instead of having to seek it in an unwieldy file of related papers. Generally, it is the specific document that is sought for complete information, as the gist of all papers on the matter under consideration appears on the card index. To bring the papers together in the files is therefore unnecessary, especially if the disadvantage of a bulky file is to be avoided. It is better to give a new accession number to each distinct step in the matter, distributing the papers over a wide range of pigeon-holes, as it were, and connecting these in the finder or index.

In the Dewey system the headings are likely to be too comprehensive or carried to too great detail; matters are filed within the restricted limits of the ready-made classed catalog and not to suit the convenience of the inquirer—the square peg behind being made to fit the round hole. Under this method a letter treating of two or more subjects is filed under one, with sheets containing references to the original letter under the related headings. With the accession plan the index entry simply is repeated under each heading and the paper is produced directly.

Subject List—Headings and Their Subdivisions

The searcher is not interested in the alleged scientific arrangement of the catalog's classification; he is only concerned in securing certain material. Of course, with the numbering plan an effort is made to be consistent, but the process is followed only so far as uniform methods help clearness and assist the user. As an aid in this direction the index is compiled or edited by one person, so as to secure adherence to the subject list and to avoid having different headings for synonymous subjects with no connection shown, as occur in Poole's "Index to Periodical Literature" and other large works. For as a single exception disproves the universal statement, so the one error in an index shakes confidence in the whole work.

The following brief subject list will give an idea of some of the larger headings: Accidents, accounts, agreements, civil service, claims, investigations, leases, legislation, permits, police, real estate and supplies. Most of these larger headings are subdivided, as under accidents we enumerate the various contracts, the general matters being set down on the first card without a subhead. The primary headings agreements and contracts are subdivided in the same way. Leases are distinguished from one another according to geographic location of premises; real estate is refined into sections and parcels, and supplies according to kind, while the civil-service class is subdivided into titles followed by the name of the employee. Thus the employee's record is always ready for inspection to date, as well as an outline history of any parcel of real estate, lease or contract, making the keeping of such additional records unnecessary.

Unit cabinets for vertical filing are used, and metal-tipped guide cards are inserted every 100 numbers. Manila folders have also been found to help to prevent post cards and the like from lodging horizontally on the floor of the drawer or slipping through the block slit. The drawers may be arranged to hold 1,000 file numbers, so that the location of, say, 44215 is drawer 44, folder 2. The index cards are kept in tray cabinets with screw rods

hat lock in the cards securing them against being easily removed, misplaced or lost.

The charging of a paper from the files is a simple business operation. When a paper is borrowed, an "out" card is filed as a receipt under the file number of the communication. Accordingly, when the loan is returned, the "out" entry is canceled in the borrower's presence. All papers must be charged in this library fashion. The person charged is held responsible, for he is requested to see that credit is given for papers returned. If outstanding papers are not renewed in a reasonable time, a notice is sent to the borrower. No person is permitted to remove papers from the files when it is possible to notify one of the filing clerks, and under no circumstances must papers be replaced in the files by other than the person assigned to that duty

Spruce Piles Cannot Stand Compacted Gravel

By Charles T. Main* and Henry E. Sawtell

In deciding upon the character of foundations to be used for the new buildings of the Massachusetts Institute of Technology, Cambridge, we found it necessary to take a great many borings. In much of the work the variation from one point to another was so rapid that repeated tests were made. Not only were borings taken and the conditions analyzed, but also a considerable number of test piles were driven, tested for load-bearing capacity and then pulled to observe the effect upon the point of the pile. It was decided that spruce piles would not be satisfactory under the existing conditions and that oak or some other hard material would have to be used.

The block plan of the group of buildings, Fig. 1, indicates the locations of 70 test borings, which are numbered chronologically. This chart shows the locations of the five spruce piles represented by the accompanying photographs. Many more piles were driven than those thus located, but a study of the character of the soil as given in the chart will throw some light upon the effect the different strata had upon the points of the piles.

The cross-sections through selected borings, Fig. 2, are quite illuminating. It will be noticed that the glacial deposit of sand, with some gravel lying immediately above the clay, shows a great variation in thickness, sometimes tapering to almost nothing. The variation in thickness of this deposit is from practically zero on boring No. 12, near the northwest corner of the building, to 29 ft. 5 in. in boring No. 22, under the west wing of the building, located only 330 ft. from No. 12.

The clay found under the glacial gravel was remarkable for its uniformity. It was only slightly plastic, being neither stiff nor soft, except in a very few places. It was devoid of excess moisture and almost free from a hard crust. In spite of this favorable condition, however, practically all the spruce piles driven down into the gravel were found upon pulling to be badly broomed or both broomed and broken. Because of this fact the load tests made on a few of them were inconclusive and could not be relied upon as guides in designing the footings.

Spruce pile No. 5, for instance, shown at the left in Fig. 3, was driven with a 2,300-lb. hammer. This pile had a 6-in. tip and an 11-in. butt. It showed an average settlement during the last few blows of $\frac{5}{8}$ in. per blow under an average hammer drop of 6 ft. 2 in. Under these conditions the load value, according to the *Engineering News* formula $P = \frac{s+1}{2Wh}$, was 8.77 tons. This pile passed through about 9 ft. 7 in. of loose sand, silt, shells

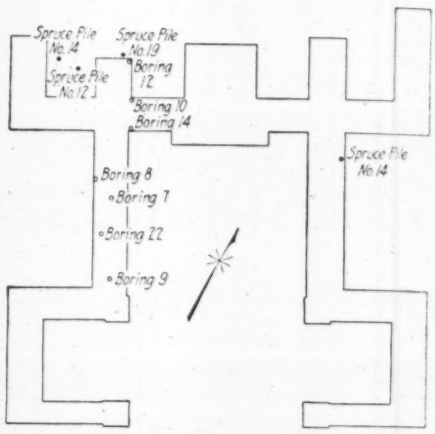

FIG. 1. BLOCK PLAN OF BUILDINGS, SHOWING LOCATION OF TEST BORINGS

and black mud and penetrated the coarse sand and gravel about 61 in. When pulled, it was found both broomed and broken a little above the top of the gravel. This pile was tested under load and showed a settlement of only $\frac{1}{32}$ in. with 6.8 tons. For increasing loads, however, it settled quite rapidly until $\frac{7}{16}$ in. was reached under 18 tons and more than 1 in. under 20 tons. The pile showed a marked tendency to get out of plumb and was wholly unreliable as a guide.

Another spruce pile, which had a butt diameter of 10 in., with a 6-in. tip, and which was 18 ft. 4 in. long, was

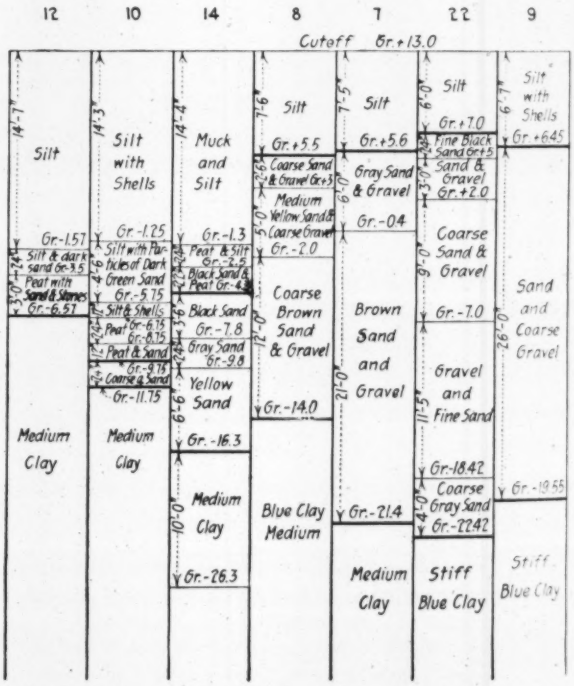

FIG. 2. CROSS-SECTIONS THROUGH SOME OF THE TEST BORINGS

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driven with the same hammer as No. 5, and during the last blows showed an average settlement of 1¾ in. under a drop of 10 ft. This gives a carrying value of 8.4 tons. This pile, which afterward was found broken and broomed below the top of the gravel, passed through 9 ft. 2 in. of loose sand, gravel, shells and mud-fill. It had penetrated the glacial gravel deposit about 5 ft. 9 in. After settling ⅛ in. with a load of 3 tons the rate of settlement of this pile became quite rapid, amounting to more than 1 in. with 15 tons and more than 3 in. with 32¾ tons. The effect of the brooming is shown by the recovery of ½ in. after the load was removed.

These tests made it quite evident that spruce piles could not be driven with safety into the harder portions of this glacial deposit. After studying these results for a number of test piles driven, it was decided to limit the use of spruce to those places where dependence had to be placed largely upon friction for bearing value, for it was plain that little dependence could be placed on point bearing.

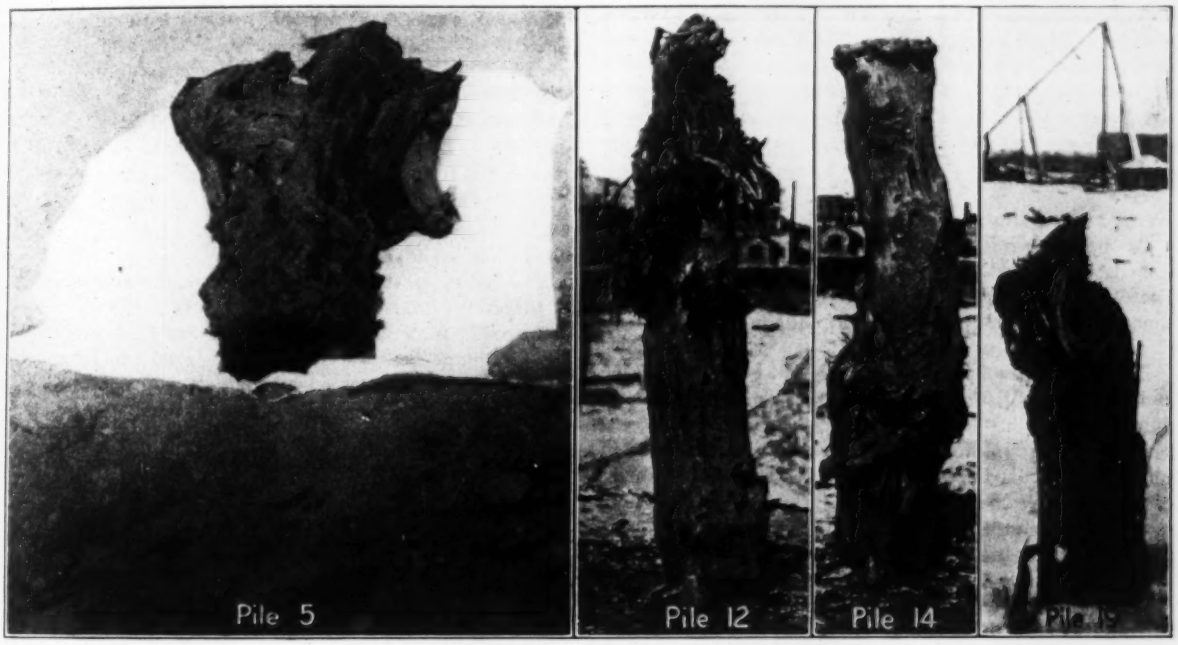

FIG. 3. DISTORTION OF SPRUCE TEST PILES CAUSED BY DRIVING IN DIFFICULT GROUND

The tests showed, furthermore, that spruce piles which appeared satisfactory to the piling foreman and the inspector were, after driving, broken and broomed near the point. Thus it was out of the question to use spruce where sudden changes in the hardness of the soil were found or were to be expected.

At the same time, tests indicated that first-class oak piles could be driven without injury into well-compacted coarse sand or fine gravel to a resistance giving a bearing value of 18 tons or more. For this reason oak piles were used for the foundations where the driving was hard and where the supporting value was to be obtained largely from point bearing and relatively small penetration in the hard stratum.

The assumption was made that if any settlement occurs on this site, owing to the weight of the buildings, it will be in the clay. To reduce this settlement to a minimum, it was decided to spread out the building loads over the glacial gravel as much as possible. This practice was depended upon to extend the loads still further over the clay bed. As it was desired to provide for the wide distribution of load on the gravel in the most uniform manner, with a resulting low pressure per square foot, it was decided to use a large number of wooden piles, each sustaining a relatively small load, rather than a few heavily loaded piles. This condition made it inadvisable to use concrete piles.

Co-operation of Engineering Activities by States

A single engineering association for each state, representing all the engineering organizations within that state, was one of the plans suggested at the recent conference on engineering coöperation in Chicago.

Under this plan, presented by Paul Hansen, Chief Engineer of the Illinois State Board of Health, all effort to maintain a professional classification would be abandoned, and the state and local societies would be opened to all engineers. Instead of being devoted primarily to the presentation and publication of papers of a technical character they would be devoted to promoting engineering activities. This would include not only general activities, but even specific improvements, such as a new road, river improvement or land-reclamation project.

This may be accomplished, in Mr. Hansen's opinion, by the state engineering society encouraging the formation of sections, largely autonomous in character and devoted to any idea or purpose in which engineers may be interested. These sections should admit to their membership not only engineers but others interested in the subject or project which the section was formed to promote. It is not advisable that persons not engineers should be admitted to membership in the society, but merely to the section, for which privilege a nominal fee may be charged. City engineers' clubs might also constitute sections of the state societies.

Economy of Continuity in Reinforced Concrete

By Raymond J. Roark*

An interesting theoretical study of the relative economy of continuous and noncontinuous reinforced-concrete girders can be made on the basis of average maximum moments and shears. By making use also of the maximum moments and shears a way is provided for making rapid estimates of the amounts of steel and concrete required in any given case. This method, as discussed herewith, is particularly applicable to the reinforced-concrete viaduct of girder type, where the quantities involved are such as to warrant detailed analysis and relatively accurate design.

The quantity of steel required as reinforcement against bending will first be considered. Assuming a constant-moment arm for the steel, the area of reinforcement at any section of the beam is proportional to M, the maximum bending moment at that section. Hence, the volume of steel required in any span is proportional to the average maximum moment in that span. Now, for any given type of beam and loading, M can be expressed in terms of x, the distance from the left end of the span to the section in question, and the total load on the beam. The evaluation of $\frac{I}{L}\int_o^L M dx$, where L is the span, will then give the average maximum moment desired.

In the following analysis two kinds of loading will be considered—a load W uniformly distributed over the span (hereafter referred to as the dead-load) and a single concentrated load P placed for maximum effect (hereafter referred to as the live-load).

The average moment due to dead-load is readily found, and the work will not be given here. The average maximum moment due to live-load is also easily found for a beam simply supported at both ends, but in the case of continuous or fixed-end beams the problem is much more complex. Here the moment at any section is a function, not only of x, but also of k, where kL is the distance from the left end of the span to the load P. It is therefore necessary to find, in terms of x, that value of k for which the moment at any section is a maximum and thus express M in terms of x and P alone. It is also necessary to consider both positive and negative moments and to take into account, in the case of continuous beams, the effect of loads in spans other than the one in question. Furthermore, allowance must be made for the balancing effect of the dead-load, the ever present dead-load moments neutralizing, over part of the beam, the live-load moments of opposite sign. By assuming various ratios of P to W this can be done and the average maximum moments due to combined dead- and live-load thus found.

The method of analysis can best be explained by discussion of a particular case. The middle span of a continuous beam of three equal spans will be considered. Fig. 1 shows the diagrams of maximum live-load moments; positive moments are plotted above, negative moments below, the axis. The solid-line curves represent moments caused by a load P placed for maximum effect and in the span in question. The broken-line curves represent moments caused by a load P placed for maximum effect and in the two end spans. The equations of the various curves were found in the manner already indicated. Thus for the case in hand, the equation of moments for a load P acting in the span is

$$M = -\tfrac{1}{15}PL\,(7k - 12k^2 + 5k^3) + Px - \tfrac{1}{15}Px\,(10k + 15k^2 - 10k^3)$$

This is found to have its greatest negative value when

$$k = \frac{-(24L-30x)+\sqrt{(24L-30x)^2+4(30x-15L)(10x+7L)}}{2\,(30x-15L)}$$

Substitution of this value in the moment equation gives the equation of maximum negative moments, represented by the two solid-line curves below the axis in Fig. 1.

The upper diagram of Fig. 2 shows the curves of Fig. 1 combined into a curve of maximum positive live-load moments and a curve of maximum negative live-load moments. The lower diagram represents, to the same scale, the moments due to an evenly distributed dead-load W per span, W being, in this case, equal to P. These dead-load moments reduce the live-load moments, as indicated by the dotted lines in the upper diagram. For the span under consideration the average maximum live-load moment was found to be $0.2110PL$. The correction, found by dividing the shaded area in Fig. 2 by L, is $0.025PL$. The average dead-load moment is $0.0316WL$. Hence, the resultant average maximum moment is

$$0.2110PL - 0.025PL + 0.316WL$$

which can be written, since W and P are here equal, $0.1088\,(W + P)L$.

Proceeding in the foregoing manner, the determination of the average maximum moment can be made for various ratios of P to W and for various types of beams. This has been done for values of $P \div W$ from 0 to 10 and for three types of beams—a beam simply supported at each end, a beam fixed at each end and a continuous beam of three equal spans. Values of the coefficient of $(W + P)L$ for average maximum moment have been plotted against corresponding values of the ratio $P \div W$, and the resulting curves are shown in Fig. 3. The results for the extreme cases of all dead-load and all live-load are given in Table 1.

A considerable amount of steel is usually required in the form of excess length, to provide for bond, and in the form of vertical or inclined stirrups, to provide for diagonal tension. Since both bond stress and diagonal tension stress are proportional to the vertical shear, the amount of steel so required may be regarded as proportional to the average maximum vertical shear. The value of this average maximum shear has been found for each beam for dead-load alone and for live-load alone. The

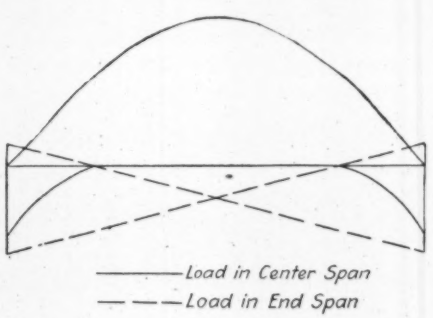

FIG. 1. MAXIMUM LIVE-LOAD MOMENTS

*Instructor in Mechanics, University of Wisconsin, Madison, Wis.

method is similar to that used in the determination of the moments, the shear S being expressed as a function of x and the load, and the value of $\frac{I}{L}\int_o^L S dx$ determined. The results are given in Table 2.

The cross-section dimensions of the girder will in general be determined by either the greatest bending moment or the greatest shear occurring in any span. Table 3 gives the values and positions of the maximum moments and shears for the beams under consideration.

Discussion of the Results

The results given in Table 1 show that the average dead-load moment for the continuous beam is $0.044WL$, while for the simple beam it is $0.0833WL$. For a uniformly distributed load it would thus appear that the continuous beam required but 53% as much steel as would a series of three simple beams of equal span. For a single concentrated load the advantage is the other way, the average maximum moments being $0.1989PL$ and $0.1660PL$ for the continuous and simple beams respectively. The former therefore requires 119% as much steel as the latter. For combined dead- and live-load the moments increase rapidly for both beams as the ratio $P \div W$ increases: but as shown by the curves of Fig. 3, the increase is more rapid for the continuous beam. The curves cross when $P \div W$ becomes equal to 2.6 approximately.

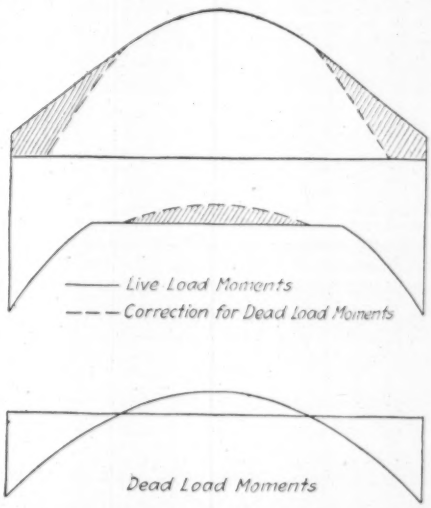

FIG. 2. COMBINED DEAD- AND LIVE-LOAD MOMENTS

The average moments are much smaller for both dead- and live-load in the case of the beam with fixed ends, and this is true for all values of $P \div W$. This would seem to show that, so far as primary stresses alone are considered, an increase in the number of continuous spans would result in a saving of steel.

The values in Table 2 show that the average shear is less for the simple beam than for either of the others. A somewhat smaller quantity of web reinforcement might therefore suffice, but the difference would be slight.

Table 3 shows that for any combination of dead- and live-load the greatest moment in a simple beam is greater than that in a continuous beam. Since the floor slab is generally an integral part of the girder, the effective section is that of a T-beam throughout in the case of the simple beam, while in the case of the continuous beam there is a T-section for positive moments and a rectangular section for negative moments. The large negative moments at the supports will therefore probably call for a greater width or depth of section than will the somewhat larger positive moment at the middle of the simple beam. If the dimensions of the girder are fixed by considerations of shear, the simple beam again has the advantage. Assuming the same average unit vertical shearing stress, the section of the continuous beam would have to be from 13% to 20% larger than that of the simple beam.

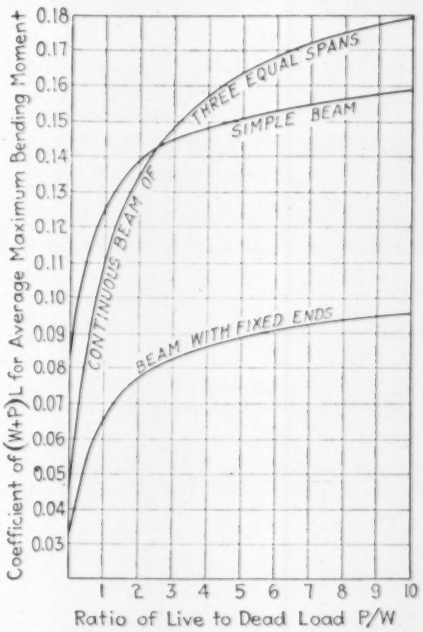

FIG. 3. BENDING-MOMENT LOAD RATIO DIAGRAM

The average and maximum moments and shears can be used to estimate very quickly the approximate amount of concrete and steel required for any girder of given span and specified loading. The section can be readily determined from the maximum moment or the maximum shear, depending on which governs in the particular case,

TABLE 1. VALUE OF AVERAGE MAXIMUM BENDING MOMENT

Kind of Beam	For Uniformly Distributed Load W per Span	For Concentrated Load P per Span
Simple	0.0833 WL	0.1667 PL
Fixed-end	0.0321 WL	0.1019 PL
Continuous (end spans)	0.0316 WL	0.2110 PL
Continuous (middle span)	0.0521 WL	0.1929 PL
Continuous (average)	0.0431 WL	0.1989 PL

TABLE 2. VALUE OF AVERAGE MAXIMUM VERTICAL SHEAR

Kind of Beam	For Uniformly Distributed Load W per Span	For Concentrated Load P per Span
Simple	0.250 W	0.750 P
Fixed-end	0.250 W	0.813 P
Continuous (end spans)	0.250 W	0.834 P
Continuous (middle span)	0.260 W	0.817 P
Continuous (average)	0.256 W	0.823 P

TABLE 3. MAXIMUM MOMENTS AND SHEARS

Kind of Beam	Maximum Positive Moment — Magnitude	Maximum Positive Moment — Position	Maximum Negative Moments — Magnitude	Maximum Negative Moments — Position	Maximum Shears
Simple	0.125 WL + 0.250 PL	Middle	0	.....	0.50 W + P
Continuous	0.080 WL + 0.214 PL	End span	0.10 WL + 0.183 PL	Supports	{ 0.6 W + 1.08 P or 0.5 W + 1.128 P
Fixed-end	0.0417 WL + 0.125 PL	Middle	0.0833 WL + 0.148 PL	Ends	0.5 W + P